# TITLE PAGE

## Small-Scale Water Efficiency Project
## Funding Opportunity No. BOR-DO-20-F006

**PROJECT TITLE:**
Greenfields Irrigation District
Electronic Water Management Plan

**APPLICANT:**
Greenfields Irrigation District
P.O. Box 157
Fairfield, Montana 59436

**PROJECT MANAGER**
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**Submitted:** February 27, 2020

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## TECHNICAL PROPOSAL AND EVALUATION CRITERIA

### (1) Executive Summary

- **Date**: February 27, 2020
- **Applicant**: Greenfields Irrigation District
- **City**: Fairfield
- **County**: Teton
- **State**: Montana

- **Project summary:**
  The Greenfields Irrigation District (District) is an aging Bureau of Reclamation (Reclamation) facility that suffers a water deficiency of 30,000 acre-feet in most years while wasting over 50,000 acre-feet into Muddy Creek. The results are shorting producers of critical water for crops and water for fish while causing significant erosion in Muddy Creek. This project proposal will take a very wasteful delivery system and upgrade electronic controls to improve water management to reduce excess wastewaters into Muddy Creek while improving instream flows in the Sun River. Specifically, this will be accomplished by automating manual flow measurements and controls at four key main canal gates. By wasting less water, the District can more efficiently use the water, reducing waste flows that currently enter Muddy Creek. These waste flows are the primary cause of huge erosion and water quality problems in the Sun River basin. The water savings will be approximately 10 additional cfs (4,000 acre-feet) over the irrigation season to be shared with irrigators and the Sun River, which has frequently gone dry or below safe levels for fish at several sites on numerous occasions over the past ten years.

  This proposal contributes to accomplishing the goals of this FOA through this specific water efficiency project providing water savings that can help fill part of the deficiency in local water needs.

- **Project length**: two years
- **Construction start:** October 2020
- **Estimated completion:** June 30, 2022
- **Federal facility:** Yes, Bureau of Reclamation facility

### (2) Background Data

The District comprises the Greenfields Division of the U.S. Bureau of Reclamation Sun River Project, Montana located in central Montana. The District is located along the Sun River drainage 35 miles northwest of the city of Great Falls. It contains 83,000 irrigable acres serving 362 water users on 1,552 farm units. The project was authorized by the Secretary of the Interior on February 26, 1906, in accordance with the act of June 17, 1902. Construction on the Greenfields Division began in 1913 and the first water was delivered in 1920. The District operates and maintains the Division facilities. District headquarters are in Fairfield, Montana.

The main storage dam, Gibson, was constructed during 1926-1929. Gibson Reservoir is located on the Sun River above Augusta, Montana, and has a total capacity of

99,058 acre-feet. Pishkun Reservoir is an off-stream reservoir, about 15 miles northeast of Gibson Dam, and has a capacity of 46,700 acre-feet. Willow Creek Dam is an earthfill structure on Willow Creek about 15 miles southeast of Gibson Dam. In addition to storing water from the natural Willow Creek drainage, the Willow Creek reservoir is fed from the Sun River through the Willow Creek Feeder Canal. The reservoir has a capacity of 32,400 acre-feet of water.

The Sun River Diversion Dam is located 3 miles downstream from Gibson Dam, feeding Pishkun Supply Canal at 1,400 cubic feet per second. Pishkun Supply Canal extends 12 miles from Sun River Diversion Dam to Pishkun Reservoir. Stemming from Pishkun Supply Canal a short distance below the river diversion, the Willow Creek Feeder Canal has a maximum capacity of 300 cubic feet per second and is 7.5 miles long to the point where it enters a natural channel to Willow Creek Reservoir.

Sun River Slope and Spring Valley Canals combined extend 32 miles from Pishkun Reservoir to a drop at Fairfield, Montana. The diversion capacity is 1,600 cubic feet per second. Three major drops and various control structures and lateral turnouts are a part of the canals. Greenfields Main Canal heads at the end of Spring Valley Canal and extends 25.4 miles northeast. It has an initial capacity of 1,200 cubic feet per second but is gradually reduced in size to 10 cubic feet per second at its terminus. Greenfields South Canal is supplied by the Greenfields Main Canal at a point about 2 miles below the start of the main canal. The initial capacity is 425 cubic feet per second and the length is 16.7 miles. Mill Coulee Canal is supplied from the Greenfields South Canal. The initial capacity is 200 cubic feet per second and the length is 10.7 miles. In total there is about 119 miles of main canal, 384 miles of laterals, and 252 miles of drains for the project.

Hydromet stations at the diversion and outlet of Pishkun Reservoir measures flows to the District. Water measurement devices have also been installed at key locations to help track water delivery. Water Inventory Data Estimation:

- Diverted from Sun River = 250,000 acre-feet
- Delivered to farm units = 150,000 acre-feet
- Transportation losses = 100,000 acre-feet
- On-farm efficiency estimated at 50-75% depending upon soils and type of irrigation

The District board passed in 2019 a <u>$1.50 increase to</u> <u>$23.50 for 2 acre/feet</u> to all assessed lands within the district. It was only four years ago when assessment was <u>increased $5.50 to $22.00</u> in an attempt to catch up on infrastructure repairs.

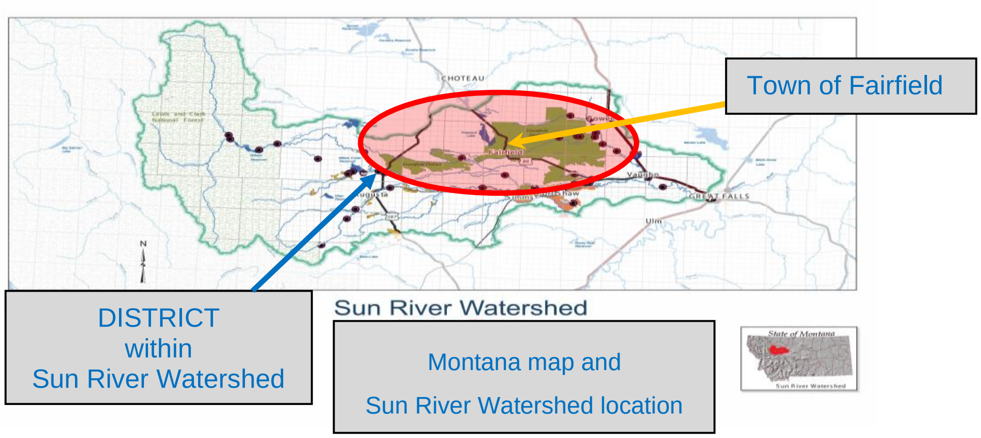
The District is located in a semi-arid climatic zone and is typical of the northern inter-mountain area. The climate is characterized by light and variable precipitation and warm and sunny days with cool nights throughout the summer months. The average annual precipitation is 11.9 inches, with an average for May through September of 8.7 inches. The Greenfields Bench receives about 30% of its water from precipitation and about 70% from irrigation supply canals. Gravity irrigation with contour ditches is 34% of irrigation used in the area. Center Pivot, wheel lines, and gated pipe are 66% of irrigation used by farm operations. The principal crops are barley, wheat, oats, alfalfa, silage, and pasture.

The average elevation of the District is approximately 3,800 feet above mean sea level. Most of the land lies within an alluvial valley floor or on adjacent terraces. Some undulation exists on those lands adjacent to the valley floor and the steeper slopes. In general, Greenfields Bench is composed up to 30 feet of gravel that overlies thick shale. The Greenfields bench geological cross-section is comprised of Quaternary terrace deposits on top of Marias River Formation (Colorado Shale), which lies on top of the Blackleaf Formation (Colorado Shale). Soils throughout the irrigation District vary significantly. Those in the alluvial valley floor have medium to heavy textures and are underlain with sands and gravels. The old river terraces adjacent to the alluvium have medium gravelly-textured profiles.

Recent working relationships with Reclamation include:

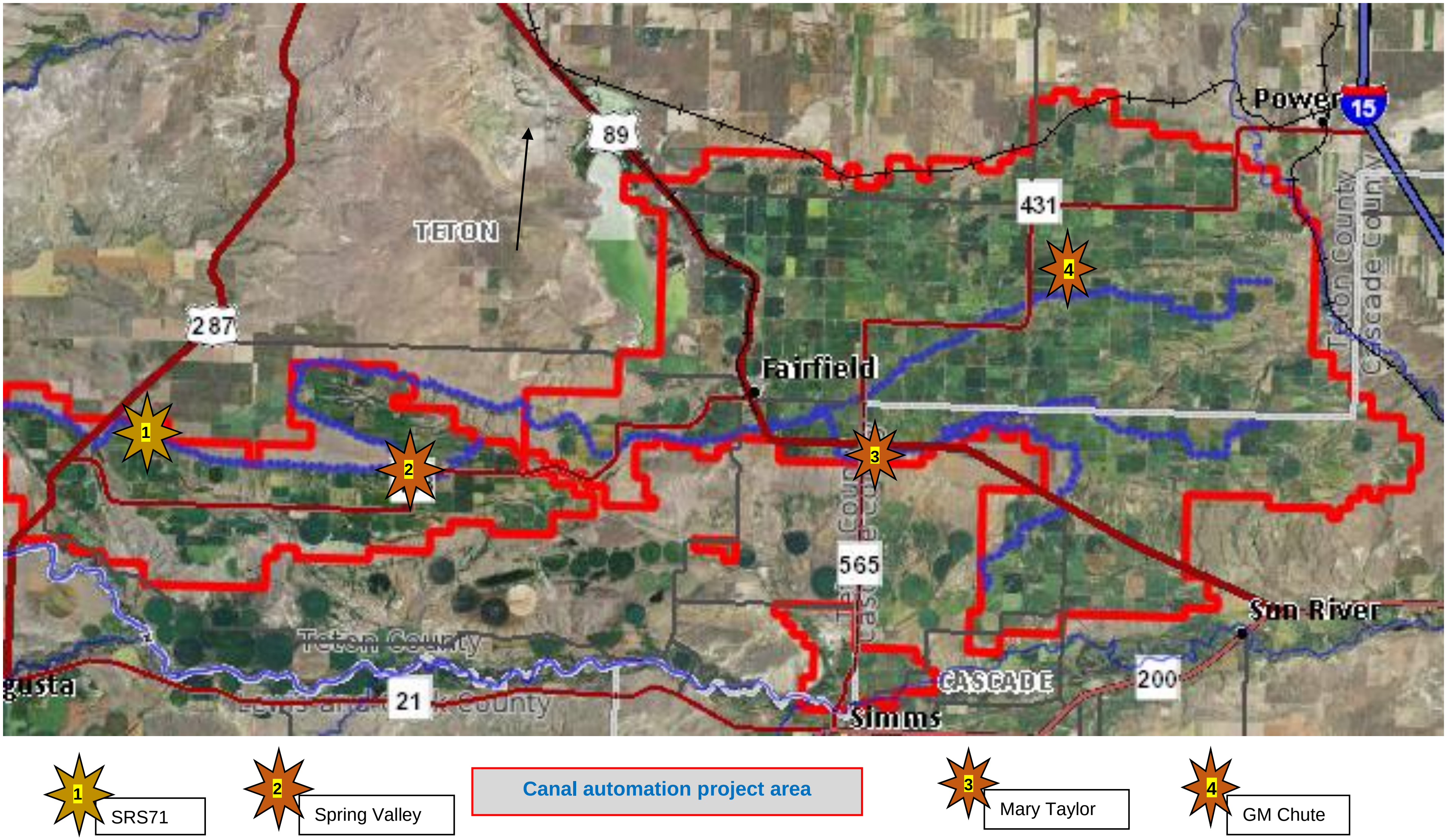
- 2019 – still going – *Sun River bridge replacement* due to deficiency repairs will cost more than bridge replacement. District and Reclamation are working on design and project funding.
- *2019* – 2020 - *WaterSMART GM100 project grant* where current GM-100 canal head gates at J-wasteway site are being replaced to help reduce tailwater into Muddy Creek. This project along with several others will decrease wastewater into Muddy Creek to a manageable level.
- *2019* – Willow Creek Reservoir outlet gates repair project due to gate valve stems failure. District designed, paid for materials and installed replacement parts. Reclamation reviewed and approved project.
- *2017-2019* – Johnson Drop replacement due to concrete failure. District designed, paid for materials and installed pipe as replacement to old concrete chute. The District installed pipe and other components to be hydro compatible so will go on-line when the time is right. Reclamation reviewed and approved project.

**Project Location:** District Electronic Water Management project is located at several sites in Teton County, Montana within 15 miles of Fairfield. The four gage locations are: #1 (SR71) latitude is 47.587592°N and longitude is 112.319077°; #2 (Spring Valley) latitude is 47.583353°N and longitude is 112.165084°; #3 (Mary Taylor) latitude is 47.605247°N and longitude is 112.948111°; and #4 (GM Chute) latitude is 47.6548672°N and longitude is 112.821835°.



# Greenfields Irrigation District

## Proposed Monitoring Sites



## (3) Technical Project Description and Milestones

### Greenfields Irrigation District Past Water Savings Activities

District is a proactive irrigation project that has an ongoing water conservation program. The process started in 1978 with a Rehabilitation and Betterment (R&B) Program. The R&B Program was completed in 1988 and included lining portions of the main canals and laterals, replacement of several open laterals and buried pipe, installation of automatic and telemetric equipment for control of water regulating facilities at Gibson and Pishkun Dams and at storage points on the irrigation system; and repairing, updating, and replacing of various structures and measuring devices.

The District has lined 120 miles of canal and lateral distribution system. The main canal was lined in areas of high seepage losses near Pishkun Reservoir as well as other areas. The major portion of lateral system has been lined with slip-form concrete.

The District embarked on a water conservation measure to save water by converting open conveyance facilities to closed pipe facilities. To date, 60 miles of open lateral system has been converted to closed concrete and PVC pipeline. The water saved is used to make up annual shortages, due to system capacity limitations during periods of high demand, or remain in storage for future use.

Operation and Maintenance Program - Annual operation and maintenance costs have been drastically reduced by the conversion of the open conveyance system to the closed pipeline conveyance system. Approximately 44 miles of existing drains were converted from an open system to a tiled or closed system to facilitate a better use of the sprinkler systems which are used by a number of the water users in the District.

The District Manager has a highly technical background and knowledge in the engineering and irrigation field. The Manager has performed training sessions for the ditchriders to broaden their knowledge in irrigation system operation and maintenance, forecasting deliveries to water users, and maintaining accurate daily water measurements and records. As a result, the District has developed a highly trained staff that can help in developing and improving the systems efficiency. District manager and staff have all had an excellent working knowledge of water conservation and management. The Manager, in conjunction with the board, supports the ongoing review and work to improve the overall condition of District facilities for water conservation.

The District developed computerized water ordering and scheduling program to improve the management of water orders and scheduling the water supply for distribution to the carriage facilities. The water users are informed by farm unit as to their usage and remaining water supply balance.

The District has HYDROMET stations at the North Fork of the Sun River, Gibson Reservoir, Diversion Dam, Pishkun Reservoir and Supply Canal, Willow Creek, and various SNOTEL sites. These stations assist the District in improved water management and inflow forecasting. The District has an Agrimet station to provide valuable data for improving on-farm efficiency of water-use. The basic components for the irrigation water management provided by Agrimet are a localized weather station capable of calculating evapo-transpiration rates for crops grown in a local area, information on the soil water holding capacity and crop water use information for stages of crop growth. A few water users within the District have been participating in the Agrimet Program over the last two years.

In summary, the District has calculated that about 40,000 acre-feet of water is being saved each year through past efforts of their water conservation program. The overall system efficiency has increased from 45% in 1979 to about 63% in 1996. The water savings and system efficiency will continue to improve as the District continues our water conservation programs.

## Greenfields Irrigation District - Current Problems and Needs

In 1982, the Bureau of Reclamation (BoR) reviewed the District's infrastructure status that identified many projects to enhance the District's efficiencies. Many of those proposed projects were accomplished in the 1980s through a Rehabilitation and Betterment Program. Despite all this activity there is much more to accomplish. In today's environment, it is more critical to find ways to work together which will include sharing the limited supply of water. The main problem areas/needs that still eludes the District are: 1) upgrading an aging infrastructure that is getting harder to maintain, 2) a shortage of 30,000 acre-feet for water users in most years, 3) controlling wastewater into Muddy Creek contributing to major erosion issues, and 4) finding win-win solutions to sharing a limited water supply.

Muddy Creek in its worst days

## Greenfields Irrigation District - Solutions to the Problems

The District is not an organization that sits around waiting for someone else to fix a problem - it is an organization that tackles problems head on, such as the items listed below:

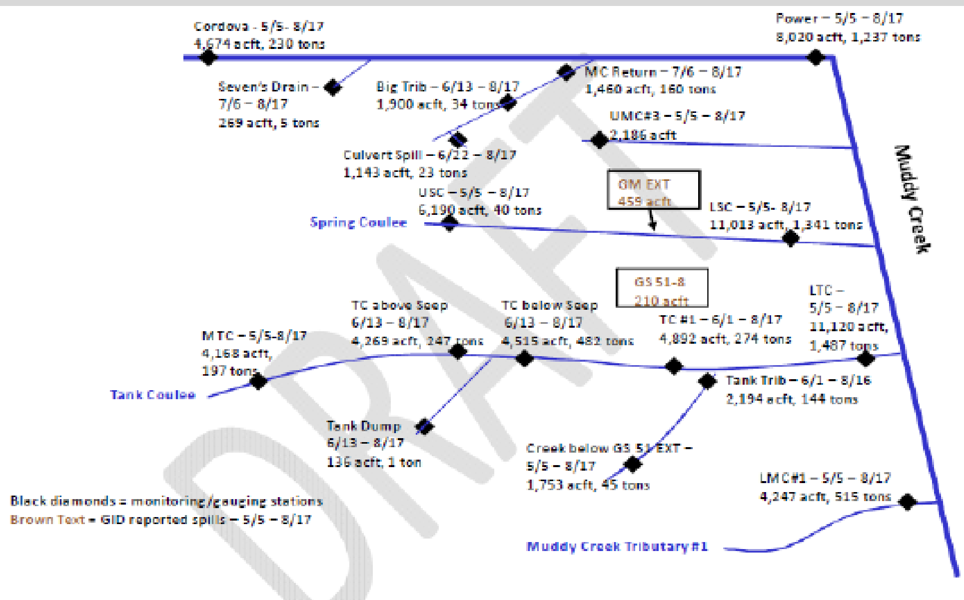
- Problem #1: Aging infrastructure that is getting harder to maintain. The District has an ongoing infrastructure maintenance schedule and is replacing many concrete structures. Examples include converting concrete chutes to pipe.
- Problem #2: Shortage of 30,000 acre-feet for water users in most years. The District is tackling this issue from several fronts including how to increase storage in existing reservoirs so can capture some of the high spring runoff flows; reuse waste water before it leaves the district boundaries such as the J-wasteway reuse; pumpbacks and installing PVC pipe to eliminate wasteful delivery systems.

- Problem #3: Controlling wastewater into Muddy Creek contributing to major erosion issues. The District has flow gauges tracking waste water entering Muddy Creek so can better manage canal deliveries; in-canal regulating gates; and reusing waste water through pumpbacks.
- Problem #4: Finding win-win solutions to sharing a limited water supply. The District actively participates in the Sun River Watershed Group's (SRWG) consensus effort that searches for win-win solutions to all-natural resource problems.

### Greenfields Irrigation District - This Project Solution to the Muddy Creek Problem

The District in cooperation with Reclamation and SRWG engaged in an extensive monitoring program to identify where the majority of the waste water and sediment loads were coming from. This data has allowed the District and SRWG to install several specific proactive water saving ventures such as the McAlpine pumpback project. This proposed project is one more step closer to controlling wastewater so the excess water in Muddy Creek will be at a manageable level that will cause minimal erosion.

One-Year of multiple year study on Muddy Creek wastewater




The District's problems #2, #3, and #4 will be one step closer to being resolved with this proposed project. The project monitoring sites were selected using data from past Reclamation/Rogers study, (see #5 for full report); Rubicon study, (see #6 for full report); Sun River Special Study, (see #7 for full report), and sites water master felt he lacked monitoring because of long water travel time ranging from 5 to 25 hours. The ***overall goal of this project*** is to improve water management of the Greenfields Irrigation District to benefit the entire Sun River Watershed. This will be accomplished by converting manual measurement operations to automated so can track and use the water efficiently which will result in less waste flows that currently enters Muddy Creek, causing huge erosion and water quality problems in the Sun River basin. The automation will comprise of electronic equipment to monitor pond level behind gates and software that allows District water master to control gate levels at District office.

This will help the irrigation district in water short years, save water for the basin to allow more water for fisheries, drinking water and other irrigators, and help improve the water quality and quantity impacted by return flows. Specifically:

**Objective 1** - Improve water management of the District (4,000 acre/feet savings) by reducing wastewater into Muddy Creek.

**Task 1** - *Bureau of Reclamation complete NEPA and NHPA* Aug - Sep 2020
- Reclamation and/or contracted services with District assistance will complete environmental and historic compliance review for the proposed project.

**Task 2** - *Final engineering, review and certification of design* Sep - Oct 2020
- District and Reclamation will work closely on final designs of project to meet all state and federal requirements.

**Task 3** – *Acquire and install measurement automation* Oct 2020 - May 2021
- Solicit and award material bids for automation, installing, calibrating
- District 3-person crew assist with installation
- District manager oversee construction phase

**Task 4** - *Reporting, compliance review and monitoring* Aug 2021 - Jun 2022
- District manager bid materials, track funds, and file reports
- District and Reclamation project compliance review
- District test system for successful installation
- District monitors water quantity for two years to track project success

**Results** - Water savings of approximately 4,000 acre-feet per year which will improve water management and improve water quantity/quality in the Sun River.

## (4) Evaluation Criteria

### *Evaluation Criterion A - Project Benefits*

- ***Describe the expected benefits and outcomes of implementing the proposed project.***
  - *What are the benefits to the applicant's water supply delivery system?*
  
    The benefits of this project to District's water supply delivery system is a more efficient use of water that runs through this aging infrastructure to help fill part of the 30,000 acre-feet almost annual shortage.
  - *If other benefits are expected explain those as well. Consider the following:*
    - *Extent to which the proposed project improves overall water supply reliability*
    
      This project will improve the overall water supply reliability significantly by gaining approximately 4,000 acre-feet of water to help fill the 30,000 acre-feet shortage the District experiences in most years.
    - *The expected geographic scope benefits from the proposed project (e.g., local, sub-basin, basin)*

The project's geographic scope will be noticed at the Sun River Watershed level by improving flows in the Sun River and at sub-basin level by reducing waste into Muddy Creek that will help reduce a major erosion problem.

- *Extent to which the proposed project will increase collaboration and information sharing among water managers in the region*
  The project will increase collaboration and information sharing when there is more water to narrow the shortages that currently exist. Water managers in the region are more inclined to work together when everyone is doing their part in finding solutions to the water shortages. With the project also reducing waste the other benefit of reducing erosion in Muddy Creek will improve teamwork.

- *Any anticipated positive impacts/benefits to local sectors and economies (e.g., agriculture, environment, recreation, tourism)*
  The anticipated positive benefits to local sectors are many including: 1) improving flows in the Sun River will improve fisheries helping the recreational and tourist water users; 2) improving water supply to farmers getting water from District will improve their cash flow which will mean more money spent locally buying new farming equipment which helps the local economy; and 3) less water entering Muddy Creek will improve water quality in Muddy Creek, Sun River and Missouri River which equates to an improved environment to everyone living and/or using the water in this area.

  The significance of the anticipated water management benefits are endless in District but primary impacts are two-fold: 1) prevent water users from shutting off early August vs irrigation need to end of September which results in huge financial loss when almost no second cutting alfalfa on approximately 30,000 irrigated acres (2 ton less per acre x $150 per ton = $9 million loss) and 2) drying up Sun River which is catastrophic for the many years in the future for almost complete loss of the fisheries.

- *Extent to which the project will complement work done in coordination with NRCS in the area (e.g., with a direct connection to the district's water supply). Describe any on-farm efficiency work that is currently being completed or is anticipated to be completed in the future using NRCS assistance through EQIP or other programs.*
  This project will directly compliment NRCS work in the Sun River Watershed that they describe as "benefit from waste reduction and improved water availability". The NRCS on-farm projects are "irrigation efficiency" through conversion from flood to sprinkler irrigation to reduce tail-water leaving each farm that in-turn will reduce excess water in Muddy Creek, the primary cause of erosion.

***Evaluation Criterion B - Planning Efforts Supporting the Project***

- ***Describe how your project is supported by an existing planning effort.***

- *Does the proposed project implement a goal or address a need or problem identified in the existing planning effort?*
  The project will address a need/problem in two different planning efforts. The first is the District's plan to become more efficient to fill the 30,000 acre-feet almost annual shortage that will in-turn reduce excess water into Muddy Creek. As identified in the Rubicon Water Scoping Study for the District it states "The long travel times in the main canal can result in significant spill, despite the best efforts of the operators. This operational spill can be reduced by using precise real-time flow controllers at key structures to enable the main canal to provide in-system storage to capture water within the system when diversions are reduced from Pishkun Reservoir in response to reduced demand.

  The second planning effort is the SRWG's plan to improve water quantity in the Sun River through a reduction of waste water from inefficient irrigation delivery systems.

- *Explain how the proposed project has been determined as a priority in the existing planning effort as opposed to other potential projects/measures.*
  This project is a higher priority because it helps fill the water District's water shortages district wide instead of projects that help a few individual water users. The District's sequential long-term goal of a main canal run by water demand as described in their Rubicon study.

***Evaluation Criterion C: Project Implementation***

- ***Describe the implementation plan of the proposed project. Please include an estimated project schedule that shows the stages and duration of the proposed work, including major tasks, milestones, and dates.***
  The stages of project implementation include:
  - #1 - BoR complete NEPA and NHPA - Aug - Sep 2020
  - #2 - BoR and District complete final engineering design - Sep - Oct 2020
  - #3 - Install electronics and program - Nov 2020 - May 2021
  - #4 - Reporting, compliance review and monitoring - Aug 2021 - Jun 2022

- ***Describe any permits that will be required, along with the process for obtaining such permits.***
  None will be required since work is on canal banks, that are modified every time the canal is cleaned.

- ***Identify and describe any engineering or design work performed specifically in support of the proposed project.***
  Design work will be for simple measurement devices and program software to automatically adjust to right water levels needed to deliver water to each canal.

- ***Describe any new policies or administrative actions required to implement the project.***
  None will be required.

***Evaluation Criterion D: Nexus to Reclamation***

- ***How is the proposed project connected to Reclamation project or activities?***
Reclamation started construction of District as part of the Sun River project in 1913 with first water delivery in 1920. Another part of the Sun River project is the Fort Shaw Irrigation District which this project will benefit also by increasing water availability to the river. Reclamation continues to be a major partner in District water conservation projects by providing people resources to design best ideas for the District and the SRWG collaborative effort.

  - *Does the applicant receive Reclamation project water?*
  Yes, District does receive Reclamation project water.

  - *Is the project on Reclamation project lands or involving Reclamation facilities?*
  Yes, project is on and involving Reclamation lands and facilities.

  - *Is the project in the same basin as a Reclamation project or activity?*
  Yes, the project is in same basin as a Reclamation project or activity. This is the Sun River basin.

  - *Will the proposed work contribute water to a basin where a Reclamation project is located?*
  Yes, proposed work will contribute water to same basin where Reclamation project is located.

    This project will be especially useful with meeting Sun River flow targets when combined with the other ongoing projects in the watershed.

  - *Will the project help Reclamation meet trust responsibilities to any tribe(s)?*
  NO. Project will not help Reclamation meet trust responsibilities to any tribe.

***Evaluation Criterion E: Department of the Interior and Bureau of Reclamation Priorities***

- ***Department Priorities***
  1. *Creating a conservation stewardship legacy second only to Teddy Roosevelt*

     a. *Utilize science to identify best practices to manage land and water resources and adapt to changes in the environment;*
     The District utilizes science to identify best management practices for all major decisions. For this project the District reached out to new innovative tools from Rubicon to control water deliveries in the main canal. For adapting to changes, the climate issue with snow melt coming off earlier and faster is why the District is looking into expanding reservoir storage – one of the few ways to take advantage of mountain water that is no longer lasting later into the summer.

     b. *Examine land use planning processes and land use designations that govern public use and access;*
     The District is an active participant in the SRWG collaborative effort where land use planning is always a discussion item. With all the major players at the table

the issues of public use and access are addressed before they become a thorn to anyone. The SRWG receiving national recognition for its many achievements is proof in itself.

c. *Revise and streamline the environmental and regulatory review process while maintaining environmental standards;*
The SRWG's consensus process in projects evaluation reduces conflict and speeds up getting ideas permitted while maintain environmental standards. The best way to ensure everyone is doing the right thing with projects like this is to get opinions early before going through official regulatory processes.

d. *Review Department water storage, transportation, and distribution systems to identify opportunities to resolve conflicts and expand capacity;*
The District has identified several sites where water storage can be expanded which will help reduce conflicts. The largest single water storage project is enlarging Pishkun Reservoir to capture water early on during snowmelt. The next that the District is just starting is in-canal storage using larger checks to control and hold more water. That is why this project is so important – can reduce waste which reduces water being transported so less waste.

e. *Foster relationships with conservation organizations advocating for balanced stewardship and use of public lands;*
The District actively participates in the SRWG consensus process with over 30 other groups that are involved, resolving differences upfront instead of later when conflicts can become very heated.

f. *Identify and implement initiatives to expand access to Department lands for hunting and fishing;*
The District already allows full access to anyone wanting to hunt or fish on lands the District manages or owns. So nothing to expand at this time.

g. *Shift the balance towards providing greater public access to public lands over restrictions to access.*
The District already allows full access to the public on lands the District manages or owns.

2. *Utilizing our natural resources* – *NONE APPLICABLE*

3. *Restoring trust with local communities*

a. *Be a better neighbor with those closest to our resources by improving dialogue and relationships with persons and entities bordering our lands;*
The District is an active participant in the SRWG consensus process that has been crucial tool to improving dialogue and relationships. With human interaction, there will always be new issues that surface so staying on top of them as they occur has been a great way the SRWG resolves conflicts.

b. *Expand the lines of communication with Governors, state natural resource offices, Fish and Wildlife offices, water authorities, county commissioners, Tribes, and local communities.*

The SRWG includes all levels of government to help keep lines of communication open. This does not mean every group is at every meeting – it means everyone is offered the opportunity to discuss ANY issue upfront before it becomes a big problem.

4. *Striking a regulatory balance* – *NONE APPLICABLE*

5. *Modernizing our infrastructure*
   a. *Support the White House Public/Private Partnership Initiative to modernize U.S. infrastructure;*
      The District is actively engaged in infrastructure modernization through public and private partnerships which includes Reclamation grants, State of Montana Renewable Resource grants, private companies donating time to help find new ways to improve infrastructure. With infrastructure costs increasing and funding decreasing, the many partnerships this District gets involved with is the only way to get on-the-ground projects completed. The hydro-project partnership is a recent collaborative project completed that is already helping pay for other projects.

   b. *Remove impediments to infrastructure development and facilitate private sector efforts to construct infrastructure projects serving American needs;*
      The District is taking advantage of simplifying hydro-power projects on irrigation projects. The District is combining several more infrastructure improvements by making them hydro-power compatible.

   c. *Prioritize DOI infrastructure needs to highlight:*
      1. *Construction of infrastructure;*
         The District has an aggressive infrastructure construction program. At the time of this grant submittal, the District has one major project being completed with at least four more starting right now.

      2. *Cyclical maintenance;*
         The District has always maintained its infrastructures. Keeping up with canal cleaning, concrete repairs or actual structure replacement when it is time has been best way for the District to on top of cyclical maintenance.

      3. *Deferred maintenance.*
         The District has a long-deferred maintenance list because it is handling many major projects before tackling many minor ones. But as the District is in the area of a deferred maintenance, they try to accomplish any repair necessary.

***Reclamation Priorities***

*1. Increase Water Supplies, Storage, and Reliability under WIIN and other Authorities*
The District is working with Reclamation staff on plans to increase water supplies and storage. List includes enlarging Pishkun Reservoir and using in-canal checks to hold water.

*2. Streamline Regulatory Processes and Remove Unnecessary Burdens to Provide More Water and Power Supply Reliability* - NONE APPLICABLE

*3. Leverage Science and Technology to Improve Water Supply Reliability to Communities* - The District has brought in several experts of new technology to improve water reliability to communities. One such possible project being discussed in this area is a large multi-community drinking water supply project.

*4. Address Ongoing Drought* - This project will address a part of the ongoing drought issue by supplying an additional 4,000 acre-feet to all water users. The District has completed and is working on several more projects to conserve water so easier to deal with drought. The projects include converted several open ditches to pipelines; installed pump-back systems; and enlarging impoundments.

*5. Improve the Value of Hydropower to Reclamation Power Customers*
NONE APPLICABLE

*6. Improve Water Supplies for Tribal and Rural Communities*
NONE APPLICABLE

*7. Implementation of new Title Transfer authority pursuant to P.L. 116-9*
NONE APPLICABLE

**Performance Measures**

Estimated water savings of approximately 4,000 acre/feet annually benefiting the reliability of water for the irrigation district while improving the water quality and quantity for all other uses in the basin.

Pre-project: Flow measurements have already been taken to identify potential savings

Post-project: Gauges on the Sun River, flow measurements on the canals, flow measurements on the wastewater by the District and SRWG will help track all water savings. See attachment #8 on page 35 for Sun River flow data and attachment #9 on page 36 for Muddy Creek flow data.

## PROJECT BUDGET

- **Funding plan and Letters of Commitment**

See attachments #2 for District letter of commitment

The District contributions to this project are $85,628 in-kind services of labor and equipment to install automation. Program grant funds for $75,000 are requested. Total project cost is $160,628.

These non-Reclamation funds and in-kind services exceed the 50% match required from this Challenge Grant program.

## General Requirements

**Task 1** - BoR complete NEPA and NHPA
- BoR or contracted services and with District complete compliance work
    - BoR or contractor to accomplish - $3,000 - Grant
    - District manager - 10 hours x $78/hour - $ 780 - In-kind

**Task 2** - BoR and District complete engineering, review and certification of design
- BoR and District will work closely on final designs
    - BoR resources to accomplish - $2,000 - Grant
    - District manager - 10 hours @ $78/hour - $ 780 - In-kind

**Task 3** - Install canal gate automation
- *District prepare and award bid for automation equipment and setup*
    - District labor - $ 980 - In-kind
        District manager - 10 hours @ $78/hour
        secretary - 10 hours @ $20/hour
    - Buy automation equipment and contract to set up - $55,000 – Grant
    - Contractor set up equipment - $ 5,000 - Grant
- New electrical power lines to sites ($20,000) $10,000 District - $10,000 - Grant

- *District crew*
    - District labor to accomplish core work including:
        - installing stilling wells for measurement devices
        - installing concrete forms and pouring concrete for unit pads
        - installing conduit and wiring for electronic devices
        - 1,155 total hours for 3 people @ $32/hour - $36,960 - In-kind
        - 15 total hours for excavator @ $62/hour - $ 930 - In-kind
        - conduit, wire, clamps $20/foot x 1,000 feet - $20,000 - match
        - concrete for gage pads $150/yard x 32 yards - $ 4,800 - match
    - District manager - to oversee proper installation
        - 20 hours @ $78/hour - $ 1,560 - In-kind

**Task 4** - Reporting, compliance review and monitoring

- District manager and secretary accomplish required grant and project monthly and final reporting and billing
    - District manager 20 hours @ $78/hour - $1,560 - In-kind
    - secretary 20 hours @ $20/hour - $ 400 - In-kind
- BoR final project inspection
- District staff monitor flow over 2 years for new gage rating curves
    - 80 hours @ $35/hour - $2,800 - In-kind

**Other expenses** - contingency and indirect
- NONE
- Indirect costs District may incur including postage, paper, and incidental labor
    - $80,590 District in-kind @ 5% = - $4,078 - In-kind

**TOTALS** **$85,628 Match** **$75,000 Grant**

**Table 1. - Summary of non-Federal and Federal funding sources**

| **Funding Sources** | **Funding Amount** |
|---|---|
| Non-Federal Entities | |
| 1. District - in-kind and cash | $ 85,628 |
| | |
| *Non-Federal Subtotal:* | $ 85,628 |
| | |
| Other Federal Entities | |
| 1. None | |
| *Other Federal Subtotal:* | -0- |
| | |
| *Requested Reclamation Funding:* | $ 75,000 |
| | |
| *Total Project Funding* | $ 160,628 |

**Budget Proposal:**

**Table 2. - Funding Sources**

| **Funding sources** | **% of Total Project Cost** | **Total Cost by Source** |
|---|---|---|
| Recipient Funding | 53% | $85,628 |
| Reclamation Funding | 47% | $75,000 |
| | | |
| **Totals →** | | **$160,628** |

## Table 3. - Budget Proposal

| BUDGET ITEM DESCRIPTION | COMPUTATION | | RECIPIENT/ PARTNERS COST SHARE | RECLAMATION FUNDING | TOTAL COST |
|---|---|---|---|---|---|
| | Unit/price | Quantity | | | |
| **SALARIES AND WAGES** | | | | | |
| **-** Employee 1 - worker | $32/hour | 385 | $ 12,320 | $ 0 | $ 12,320 |
| **-** Employee 2 - worker | $32/hour | 385 | $ 12,320 | $ 0 | $ 12,320 |
| - Employee 3 - worker | $32/hour | 385 | $ 12,320 | $ 0 | $ 12,320 |
| - Employee 4 - oversight | $78/hour | 20 | $ 1,560 | $ 0 | $ 1,560 |
| **EQUIPMENT** | | | | | |
| Excavator | $62/hour | 15 | $ 930 | $ 0 | $ 930 |
| Basic tools for concrete & pipe work | ----- | --- | --- | --- | --- |
| | | | | | |
| **SUPPLIES/MATERIALS** | | | | | |
| Conduit, wire, clamps, etc | $20/foot | 1,000 | $ 20,000 | $ 0 | $ 20,000 |
| Concrete | $150/yard | 32 | $ 4,800 | $ 0 | $ 4,800 |
| Electronic equipment/ software | $55,000 | 1 | $ 0 | $ 55,000 | $ 55,000 |
| | | | | | |
| **CONTRACTUAL** | | | | | |
| - Equipment setup | $5,000 | 1 | $ 0 | $ 5,000 | $ 5,000 |
| -Electrical power lines | $10,000 | 2 | $ 10,000 | $ 10,000 | $ 20,000 |
| | | | | | |
| **OTHER** | | | | | |
| Reporting | $20.00/ hour | 30 | $ 600 | $ 0 | $ 600 |
| Compliance & reporting | $78.00/hour | 50 | $ 3,900 | $ 0 | $ 3,900 |
| Monitoring - flows | $35.00/ hour | 80 | $ 2,800 | $ 0 | $ 2,800 |
| NEPA/NHPA - USBR | $3,000 | 1 | $ 0 | $ 3,000 | $ 3,000 |
| Engineering review | $2,000 | 1 | $ 0 | $ 2,000 | $ 2,000 |
| **TOTAL DIRECT COSTS** | | | $ 81,550 | $ 75,000 | $ 156,550 |
| | | | | | |
| INDIRECT COSTS -_5_% | 5% | | $ 4,078 | $ 0 | $ 4,078 |
| | | | | | |
| **TOTAL PROJECT COSTS** | | | $ 85,628 | $ 75,000 | $ 160,628 |

## BUDGET NARRATIVE

***Salaries & Wages***

- District's program manager, Erling Juel
  - $78/hour for all work
    - 20 hours project oversight
    - 20 hours assisting in compliance review, design and permitting
- District laborers -
  - 3-person work crew, 385 hours each - $32/hour for wiring, building work
  - District Water Master - $35/hour for 80 hours over 2 years measuring flows to establish rating curve and track project results/benefits

***Fringe Benefits*** - NONE

***Travel*** - NONE

***Equipment***

- Small equipment/tools to install wire, pipe and pour concrete
- Excavator to dig holes for stilling wells and concrete work $62/hour x 15 hours

***Materials & Supplies***

- All materials below are for construction purposes and were estimated by acquiring quotes from local distributors
  - Automation/gage equipment = $55,000 (grant)
  - Conduit, wire, clamps, etc = $20 per foot for 1,000 feet
  - Concrete delivered for equipment pads $150/yard for 32 yards

***Contractual***

- District will have NEPA, NHPA and final engineer review through contracts for $5,000 (grant)
- Contract to install electronic equipment - $5,000 (grant)
- Local power company for electrical power line and hookups $20,000
  $10,000 District and $10,000 (grant)

***Environmental and Regulatory Compliance Costs***

- Part of BoR contractual costs listed above

***Reporting***

- District's program manager, Erling Juel
  - $78/hour for all work
    - 30 hours assisting in compliance review, permitting and project reporting
- District secretary
  - $20 hour for all work
    - 30 hours to specifically help with writing financial, program performance, semi-annual and final reports

***Other*** - *NONE*

***Indirect Costs***
- 5% rate District is using for any remaining costs not listed above including postage, paper, copies and other labor.                5% x $81,550 = $4,078

***Total costs***

- Entire project = $160,628
- Non-federal cost-share = $ 85,628
- Federal cost-share = $ 75,000

## Environmental and Cultural Resources Compliance

- *Will the project impact the surrounding environment (i.e., soil [dust], air, water [quality and quantity], animal habitat, etc.)? Please briefly describe all earth-disturbing work and any work that will affect the air, water, or animal habitat in the project area. Please also explain the impacts of such work on the surrounding environment and any steps that could be taken to minimize the impacts.*

- The project will have minor air disturbance during construction phase as the earth work of trenching and back-filling occurs. This will be minimized by reducing the length of time project is in construction phase.
- With extensive farming in this area, no animal habitat impacts are expected.

- *Are you aware of any species listed or proposed to be listed as a Federal endangered or threatened species, or designated Critical Habitat in the project area? If so, would they be affected by any activities associated with the proposed project?*

There are no species either listed or proposed to be listed in this area.

- *Are there wetlands or other surface waters inside the project boundaries that potentially fall under Federal Clean Water Act jurisdiction as "waters of the United States?" If so, please describe and estimate any impacts the project may have.*

No impacts to any wetlands or streams

- *When was the water delivery system constructed?*

Delivery system construction started in 1913

- *Will the project result in any modification of or effects to, individual features of an irrigation system (e.g., headgates, canals, or flumes)? If so, state when those features were constructed and describe the nature and timing of any extensive alterations or modifications to those features completed previously.*

Will be minor modification to existing canal structure when installing electronic equipment. Work will be accomplished along canal banks when digging hole for stilling well and concrete pad for electronic equipment.

- *Are any buildings, structures, or features in the irrigation district listed or eligible for listing on the National Register of Historic Places? A cultural resources specialist at your* *local Reclamation office or the State Historic Preservation Office can assist in answering this question.*

Cultural resource areas within the district do exist. Previous inventories by Reclamation have located and identified the resources that should not be disturbed. All regulatory compliance requirements are not completed at this time; however, they will be completed prior to initiation of this project. District will work closely with Reclamation to achieve compliance with both National Environmental Policy Act (NEPA) and National Historic Preservation Act (NHPA).

- *Are there any known archeological sites in the proposed project area?*

There are no known archeological sites where this work will be accomplished.

- *Will the project have a disproportionately high and adverse effect on low income or minority populations?*

The project will have a beneficial impact on low income families as it improves their ability to increase production on what is currently waste land due to seeps.

- *Will the project limit access to and ceremonial use of Indian sacred sites or result in other impacts on tribal lands?*

There are no Indian sacred sites in this area.

- *Will the project contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species known to occur in the area?*

There are noxious weeds in the area but District staff takes proactive approached to controlling the weeds and will take extra precaution not to move equipment through known old patch sites that may still have weed seeds. After construction the sites will be monitored for new weed infestations that can be controlled immediately.

**REQUIRED PERMITS OR APPROVALS**

NO PERMITS REQUIRED

**OFFICIAL RESOLUTION**

See attachment #2 on pages 25 for District resolution.

## **BUDGET FORM** – SF-424C, Budget Information

View Burden Statement

OMB Number: 4040-0008
Expiration Date: 02/28/2022

### BUDGET INFORMATION - Construction Programs

*NOTE: Certain Federal assistance programs require additional computations to arrive at the Federal share of project costs eligible for participation. If such is the case, you will be notified.*

| COST CLASSIFICATION | a. Total Cost | b. Costs Not Allowable for Participation | c. Total Allowable Costs (Columns a-b) |
|---|---|---|---|
| 1. Administrative and legal expenses | $ 4,500.00 | $ 0.00 | $ 4,500.00 |
| 2. Land, structures, rights-of-way, appraisals, etc. | $ 3,000.00 | $ 0.00 | $ 3,000.00 |
| 3. Relocation expenses and payments | $ 0.00 | $ 0.00 | $ 0.00 |
| 4. Architectural and engineering fees | $ 2,000.00 | $ 0.00 | $ 2,000.00 |
| 5. Other architectural and engineering fees | $ 0.00 | $ 0.00 | $ 0.00 |
| 6. Project inspection fees | $ 0.00 | $ 0.00 | $ 0.00 |
| 7. Site work | $ 0.00 | $ 0.00 | $ 0.00 |
| 8. Demolition and removal | $ 0.00 | $ 0.00 | $ 0.00 |
| 9. Construction | $ 143,320.00 | $ 0.00 | $ 143,320.00 |
| 10. Equipment | $ 930.00 | $ 0.00 | $ 930.00 |
| 11. Miscellaneous | $ 2,800.00 | $ 0.00 | $ 2,800.00 |
| 12. SUBTOTAL *(sum of lines 1-11)* | $ 156,550.00 | $ 0.00 | $ 156,550.00 |
| 13. Contingencies | $ 4,078.00 | $ 0.00 | $ 4,078.00 |
| 14. SUBTOTAL | $ 160,628.00 | $ 0.00 | $ 160,628.00 |
| 15. Project (program) income | $ 0.00 | $ | $ 0.00 |
| 16. TOTAL PROJECT COSTS *(subtract #15 from #14)* | $ 160,628.00 | $ 0.00 | $ 160,628.00 |
| FEDERAL FUNDING | | | |
| 17. Federal assistance requested, calculate as follows: (Consult Federal agency for Federal percentage share.) Enter the resulting Federal share. | Enter eligible costs from line 16c Multiply X [ ] % | | $ 0.00 |

# RESOLUTION

## Greenfields Irrigation District
## Board of Commissioners
## Fairfield, MT 59443

### RESOLUTION SPONSORING
### BUREAU OF RECLAMATION 2020 WATER SMART GRANT
### FOR WATER MANAGEMENT

**WHEREAS,** Greenfields Irrigation District's infrastructure is in dire need of immediate and long-term improvements to conserve water and enhance delivery to water users, and

**WHEREAS,** Greenfields Irrigation District's overall infrastructure is in need of many improvements to improve its water management for this and future generations, therefore

**BE IT RESOLVED,** the Greenfields Irrigation District's Board of Commissioners has reviewed and authorizes the district manager to pursue a Bureau of Reclamation 2020 WaterSMART grant for water management; and

**BE IT FURTHER RESOLVED,** the Greenfields Irrigation District's Board of Commissioners by the authority given to it by the State of Montana is committing the necessary resources and funds to complete the infrastructure project by June 30, 2022.

Dated this 11th day of February, 2020.

President

Attest:

Chase A Brody

Dave Gulick

William H. Norris

Attachment #2

Greenfields
IRRIGATION DISTRICT

February 12, 2020

Bureau of Reclamation
Acquisition Operations Group
Attn: Michelle Maher
Mail Code: 84-27810
P.O. Box 25004
Denver, CO 80225

RE: Letter of Commitment

Dear Bureau of Reclamation

The Greenfields Irrigation District (GID) is writing this Letter of Commitment for the 2020 Reclamation WaterSMART grant application. GID will commit up to $86,000 of in-kind labor, equipment, and materials to install the canal gate automation.

The in-kind resources will be provided by GID's construction crew team that includes 3-person crew with supervisor to install equipment. The staff and management of GID are very experienced in construction having previously and successfully completed a multi-million-dollar, hydroelectric project as well as many other infrastructure replacement projects. BoR quality assurance oversight personnel can attest to their ability to complete major projects.

Call me at 406-467-2533 if have any questions concerning this project.

Respectfully,
Greenfields Irrigation District

Erling Juel, P.E.
District Manager

X:\Grants\USBR\2020 Automation Commitment Letter.doc

P.O. Box 157, 105 West Central Avenue • Fairfield, MT 59436 • (406) 467-2533 • www.gid-mt.com

SUN RIVER
WATERSHED GROUP

February 24, 2020

Bureau of Reclamation
Water Resources and Planning Division
Attn: Ms. Robin Graber
PO Box 25007, MS 84-51000
Denver, Co 80225

RE: Greenfields Irrigation District Proposal Support
BOR-DO-20-F006

Ms. Graber:

The Sun River Watershed Group would like to express our support for Greenfields Irrigation District's (GID) 2020 WaterSMART grant application.

The Sun River Watershed Group works collaboratively to restore and protect the health of the Sun River watershed resources and its communities. This includes our goals to improve water management and water quality in the Sun River and its tributaries. For over 20 years, GID has been a key partner on projects and programs to advance both of these goals. This WaterSMART proposal will enable GID to collect data that will inform water management decisions and help quantify water conservation efforts GID has planned and in-progress.

GID is undertaking and planning several activities to improve water management, conservation, and efficiency in the Sun River watershed. The gages proposed in this WaterSMART proposal will provide important information that will be used to manage and conserve water as well as document improvements in efficiency and conservation as additional strategies are implemented. The Sun River Watershed Group feels strongly that the activities detailed in the WaterSMART proposal are vital to the health of the Sun River watershed, and that GID will successfully administer and fulfil the requirements of this grant funding.

Thank you for your consideration

TRWendt

Tracy R. Wendt
Watershed Coordinator
Sun River Watershed Group

PO Box 7312
Great Falls, MT 59406
(406) 214 2868
tracy@sunriverwatershed.org

Attachment #4

# Proposed Monitoring Sites


1 SRS 71

2 Spring Valley

3 Mary Taylor

4 GM Chute

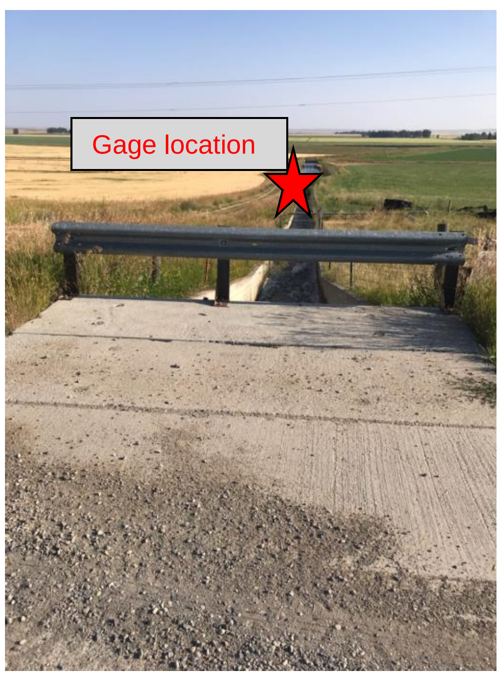
# #1 - SRS 71


# #2 - Spring Valley



# #3 - Mary Taylor


# #4 - GM Chute



See attached file #5 for full report

Greenfields Irrigation District
Canal Modernization

## CANAL CONTROL EVALUATION AND RECOMMENDATIONS

1.0 OBJECTIVES

Irrigation water from Greenfields Irrigation District (GID) contributes undesirable flow into Muddy Creek. Water entering Muddy Creek comes from a combination of subsurface drainage, surface drainage, and canal waste flows. Improvements to canal system operations can help to reduce all of these. The most direct benefit is to reduce waste flows through J Wasteway. Although GID presently operates the system with as little waste as possible, system improvements will allow further reductions in waste flows. Improved canal operations can also reduce drainage flows, by increasing the accuracy and flexibility of deliveries to farms.

An additional benefit to improved operations is to facilitate canal system management. Canal operators' jobs can be simplified by increasing the system's hydraulic and control capabilities plus providing better information on system-wide conditions (monitoring) at GID headquarters. Any changes to operating philosophy or methods must be acceptable to operating personnel. To be successful, canal operators must be comfortable with methods and equipment. Therefore, simple is usually better than complex. Technical and economic feasibility must not overlook practical application considerations.

This study and report examine different methods to improve canal operations, considering technical, economic, and social feasibility.

2.0 SUMMARY OF POTENTIAL METHODS TO IMPROVE OPERATIONS

For the purpose of this study, the GID canal system consists of the Sun River Slope Canal (SRSC), Spring Valley Canal (SVC), Greenfields Main Canal (GMC), Greenfields South Canal (GSC), Big Coulee Canal, Mill Coulee Canal, and all the attached laterals and drains. Many different methods are available to upgrade the system's operation. Possibilities are described in the sections that follow, listed in order from the simple and inexpensive to the more complex and expensive methods.

**2.1 Monitoring** - Supervisory monitoring of system-wide data from GID headquarters (master station) will continue to be valuable and can be expanded to include more data from more sites. Monitoring requires sensors (water level or gate position), remote terminal units (RTU), a communication system, master station equipment, and software.

**2.2 Supervisory Control** - Supervisory (remote) manual control allows an operator to adjust remote check gates from GID headquarters. In addition to the monitoring requirements above, supervisory control requires motorized gates, interface equipment

1

Attachment #6

See attached file #6 for full report

# Rubicon Water Scoping Study

Greenfields Irrigation District

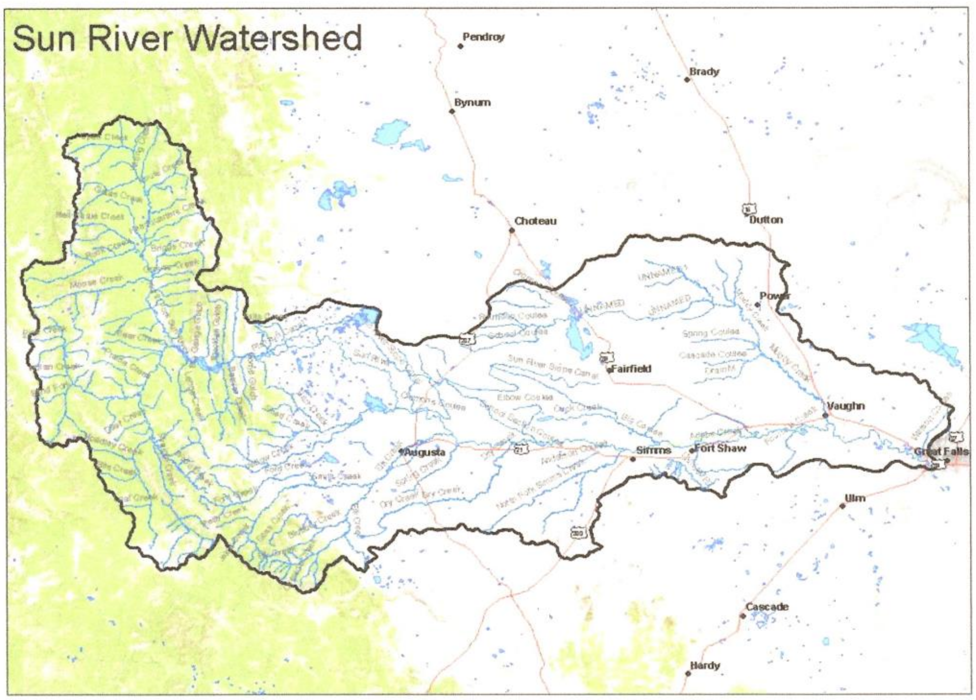
## Main Canal

**January 2016**

RUBICON™

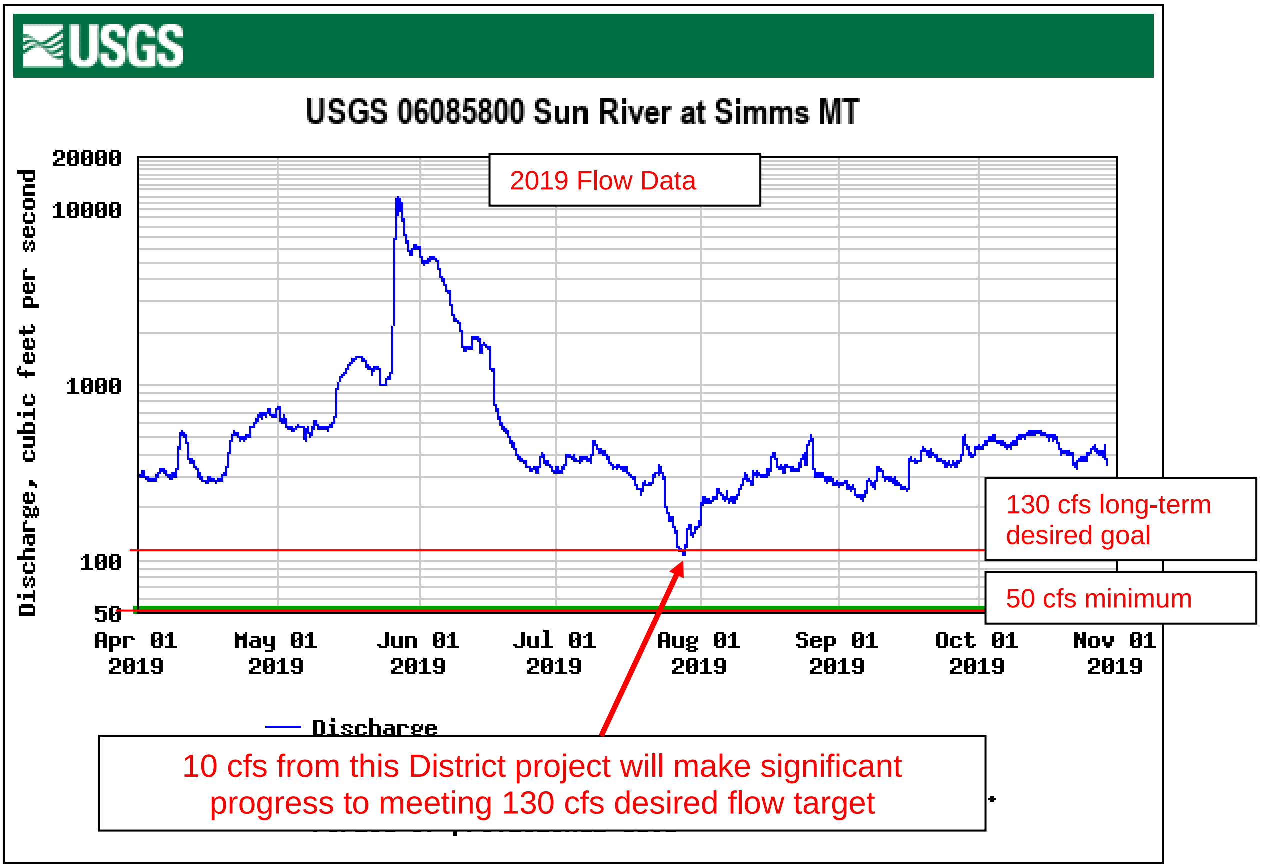
See attached file #7 for full report

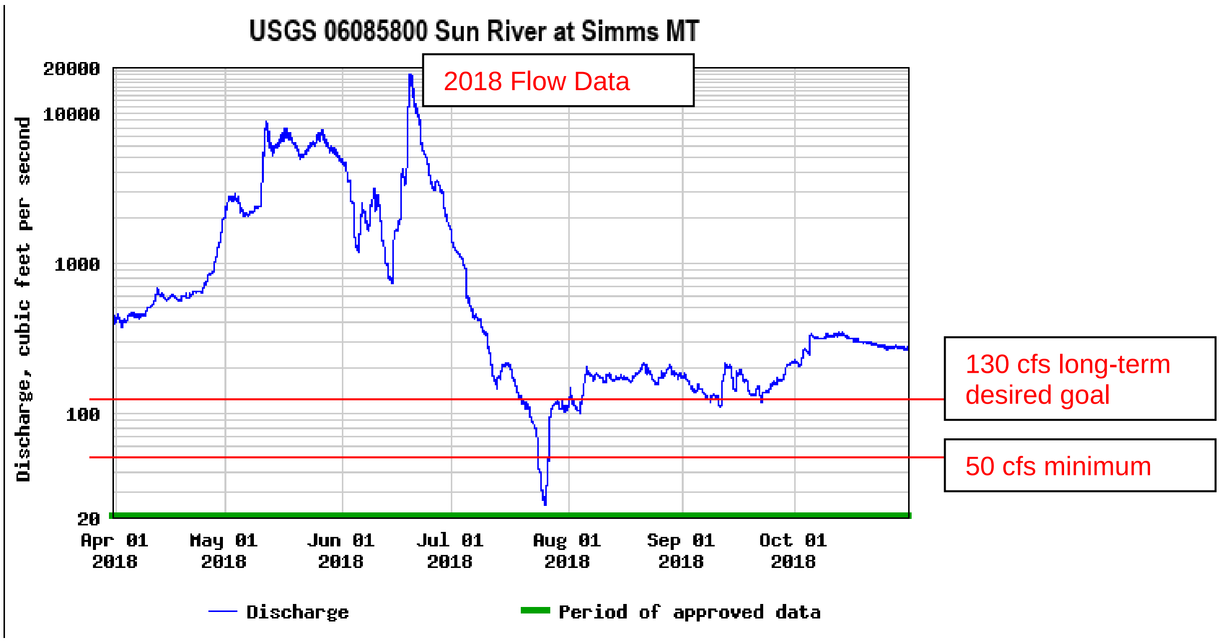
# SUN RIVER WATERSHED GROUP SPECIAL STUDY REPORT




**Prepared by:**
**Sun River Watershed Group in Cooperation with the U.S. Department of Interior Bureau of Reclamation, and Montana Department of Natural Resources and Conservation**
**December, 2012**

# USGS flow data in Sun River at Simms used to track lower Sun River flow conditions (130 desired minimum flow)



Attachment #9

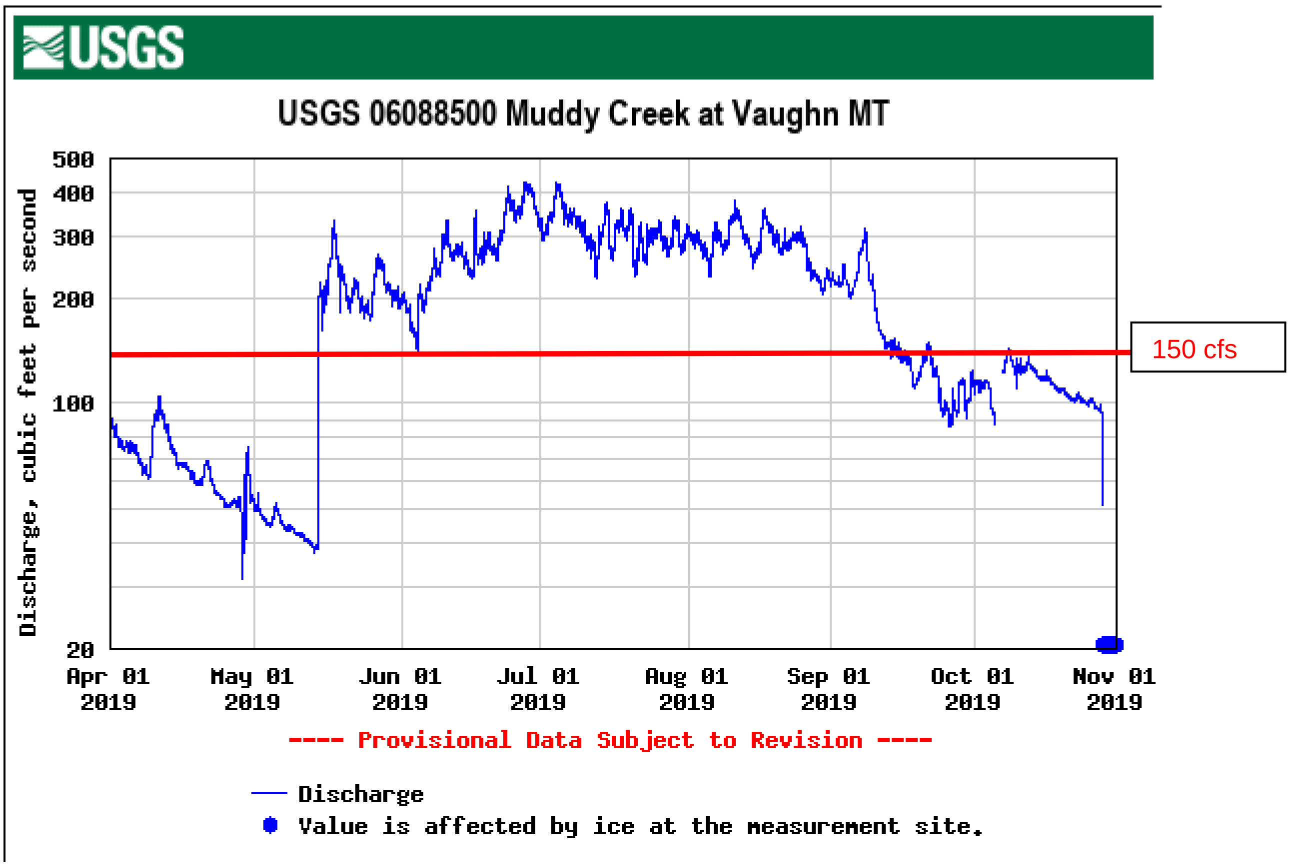
# Muddy Creek Flow data

Tail Water from 50,000 acres of Greenfields Irrigation District

Desired flow is less than 150 cfs when erosion is almost none

and

Extra water can be used to reduce impacts of drought and more instream flows in Sun River



# CANAL CONTROL EVALUATION AND RECOMMENDATIONS

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This study and report examine different methods to improve canal operations, considering technical, economic, and social feasibility.

## 2.0 SUMMARY OF POTENTIAL METHODS TO IMPROVE OPERATIONS

For the purpose of this study, the GID canal system consists of the Sun River Slope Canal (SRSC), Spring Valley Canal (SVC), Greenfields Main Canal (GMC), Greenfields South Canal (GSC), Big Coulee Canal, Mill Coulee Canal, and all the attached laterals and drains. Many different methods are available to upgrade the system's operation. Possibilities are described in the sections that follow, listed in order from the simple and inexpensive to the more complex and expensive methods.

**2.1 Monitoring** - Supervisory monitoring of system-wide data from GID headquarters (master station) will continue to be valuable and can be expanded to include more data from more sites. Monitoring requires sensors (water level or gate position), remote terminal units (RTU), a communication system, master station equipment, and software.

**2.2 Supervisory Control** - Supervisory (remote) manual control allows an operator to adjust remote check gates from GID headquarters. In addition to the monitoring requirements above, supervisory control requires motorized gates, interface equipment (interface between RTU and gate motor), and additional software at the RTU and at the master station.

**2.3 Local Automatic Control** - an automatic feedback controller can maintain a constant water level in the canal by adjusting the adjacent check gate(s), without human intervention. Several GID check structures were previously configured for automatic level control but are not operational. Adding local automatic control requires little additional equipment beyond that required for supervisory control, but software must be developed and added to the site, including alarms to alert operators if a problem develops.

**2.4 J Lake** - Additional regulatory storage in the canal system will improve operations by allowing canal flow to remain steady while deliveries to water users change. Section 3.2 below discusses this option.

**2.5 Modifications at Existing Structures** - Structural modifications could improve control capabilities at some existing structures. Possibilities include replacing gates and hoists, adding power, adding gate motors, and raising check structure walls. For example, the SVC headgate and SVC-35 Check would require modifications before they could be remotely or automatically controlled.

**2.6 Additional Structures** - Adding more check structures will improve system response and overall performance. This option was explored in the 1993 report discussed in section 3.1 below.

## 3.0 EVALUATION OF PREVIOUS PLANS

**3.1 Multiple Check Structure Scheme** - The 1993 report by Lee, Bates, and Bates addresses potential improvements to GID's main canal. This report is a valuable piece of work that includes a good compilation of canal operation records and has many good suggestions. However, the authors missed some important considerations.

The report's strong points include the following:

- In general, the hydraulic computations are correct. Appropriate methods were used and most of the numerical results appear to be accurate. Spot checks of numerical computation revealed some inaccuracies in backwater profiles, but these were not significant enough to change qualitative results.

- The basic premise--using additional check structures to better manage canal levels and flow--is sound. With an appropriate control system, a canal system with multiple check structures can operate efficiently with little waste while improving service to water users. This has proven successful on many modern canal systems in the U.S. and abroad.

- Site selection for additional check structures is good. Both the sites initially targeted and the final (primary) sites are logical and appropriate.

- Overshot gates are an appropriate choice for this application. Overshot gates are practical and effective when routing flow changes in the downstream direction and maintaining the upstream water level at each check. (As opposed to downstream-oriented operations where gates are adjusted to maintain downstream conditions.) Overshot gates are also relatively economical in retrofit installations.

Weaknesses in the report's assumptions and conclusions include:

- The project's basic objective--"to reduce the flow down J Wasteway by 50 cfs for a period of 36 hours"--is based on the 36-hour lag time in the present system and overlooks the benefits of the new check structures. Presently, it takes 36 hours for a flow change at the Pishkun Reservoir outlet works to reach J Wasteway. This is because the entire canal must partially drain or fill, from upstream to downstream, to reach equilibrium at a new normal depth for the new flow. ***This 36-hour lag should have no bearing on the operation of the proposed system of check structures.*** In response to a downstream flow change (change in demand), the report assumes a sequential gate operating technique progressing in the upstream direction. Pool storage volumes are computed so that this sequential operation takes 36 hours to reach the headworks. Although these calculations may be correct, there is no reason to operate the canal this way. ***It is not necessary to wait 36 hours after a change in outflow before correcting the inflow.*** Whenever the outflow changes, inflow at the head end of the canal should be adjusted as soon as possible, as should the flow at checks throughout the canal system. Then, instead of draining or filling large volumes of water for 36 hours, only small volume adjustments are required (from slight shifts in water surface profiles to reach a new steady state condition).

- The magnitude of water level fluctuations proposed in the report (up to 2 ft of depth change) is probably not practical. Although this may be acceptable for emergency operations, GID is unlikely to want this much water level variation for normal operations because of problems with seepage and maintaining constant turnout deliveries. This much water level change could also increase canal maintenance costs. (For the reasons stated in the previous paragraph, much less water level fluctuation will be required anyway.)

**3.2 J Lake Proposal** - A GID proposal (dated 3/8/96) addresses the reasons and plans for constructing a regulatory storage reservoir at the J Wasteway site. The J Lake Proposal has considerable merit to improve canal operations while reducing waste flows into Muddy Creek. Major advantages to J Lake include:

- Regulatory storage is a simple and dependable method to reduce waste flow. Once constructed, J Lake will provide long-term benefits to the district while requiring little additional cost or effort.

- GID operations can remain essentially unchanged from present methods. Operators can continue to route flow changes downstream through the canal system with any excess water diverted towards J Lake. Releases from Pishkun Reservoir will still be based on delivery schedules and then adjusted based on the water level in J Lake.

- The planned size and location for J lake appear reasonable. It should provide enough storage to prevent most of the waste through J Wasteway. The location allows most of the canal system to pass excess flow downstream to J Lake, while releases from J Lake into GM-100 Canal can be based on downstream demand. Excess water that accumulates in J Lake can be used beneficially to supply deliveries from GM-100 downstream.

- J Lake will compliment other system enhancements. Other operation improvements, such as improved monitoring and control at intermediate structures, will be compatible with the J Lake proposal.

Disadvantages to J Lake include:

- Cost is relatively high, requiring a large initial expenditure.

- Seepage and evaporation losses will increase. The amount of seepage and evaporation depends on how much water is kept in the lake.

- Some of the control details need to be pursued further. The proposal mentions computer-controlled releases into GM-100 Canal based on downstream water level. This is a good idea, but it will require additional structures, equipment, and work.

- Once full, J Lake will not be able to prevent additional waste. An event that causes successive days of delivery flow reduction, such as several days of rain, will still cause waste. Other methods to enhance system operations will be needed, in addition to J Lake, to handle these situations.

## 4.0 SITE REVIEW

**4.1 SRS-71 Check** - The first canal check structure is in SRSC near station 715. (See photo 1.) It is in excellent condition and could easily accommodate supervisory control equipment. The existing structure, radial gates, hoists, motors, and power supply all appear to be suitable without modification. Supervisory control of this site would require the following:

a) upstream water level sensor (could be mounted on check structure);
b) gate position sensor and limit switches on each gate;
c) microprocessor-based remote terminal unit (RTU) equipment;
d) radio, antenna, and tower (or other communications equipment);
e) enclosure.

With supervisory manual control from the GID headquarters, this check structure could be used to make flow changes, control the upstream water level, and take advantage of in-channel storage in the canal pool upstream.

**4.2 SVC Headgate** - The second check structure is at SRSC station 1153 where the SRSC bifurcates to SVC and the pipe drop to Big Coulee Canal. (Photo 2 and 3.) This site would need extensive modification to be suitable for remote control. Before this site could be remotely controlled, electric power would need to be brought in, gate motors added, and the gates and hoists would need to be rehabilitated or replaced. Additionally, using this check structure to vary pool storage volumes has disadvantages. Although the canal pool upstream has plenty of freeboard, fluctuating upstream water levels would interfere with the operation of canal turnouts and the Big Coulee Canal head gate.

**4.3 SVC-35 Check** - The third check structure, near SVC station 350, contains two overshot gates and several stoplog bays. (Photo 4 and 5.) At high flows, this structure is wide open and fully submerged and the adjacent canal has little freeboard. Therefore, the structure has little potential for control at high flows but may be useful for managing flow changes and upstream water levels at lesser canal flow rates. For remote control, this site would require power, gate motors, water level and gate position sensors, and RTU equipment.

**4.4 Turnbull Drops (SVC-58)** - These chutes near SVC station 581 have uncontrolled inlets, so there is no way to control the flow or upstream water levels. In order for the flow at the Turnbull Drops to change, the canal section upstream must drain or fill in response to flow changes from upstream. Attempts to change the flow downstream from the Turnbull Drops will be ineffective until water levels (and volumes) upstream from the drops have stabilized at the new flow rate. The only way to prevent this situation is to add a check structure in the canal just above the drops.

**4.5 GMC-57 Check (Mary Taylor Drop)** - The fourth check structure is near GMC station 576, at the bifurcation to Greenfields South Canal (GSC) and the Mary Taylor Drop. (Photo 6 and 7.) The structure has two radial gates at the inlet to Mary Taylor Drop and four slide gates that serve as the GSC headworks. The radial gates control the upstream water level in order to divert the desired flow into GSC. The remainder of the flow goes down Mary Taylor Drop into the continuation of GMC. GSC flow is measured at a rated section in the canal downstream. Control equipment at the site monitors upstream level and gate positions and telemeters these data via radio to GID headquarters. Additional control capabilities intended at this site are not operable.

**4.6 GMC-95 Check (Knight Chute)** - The fifth check is near GMC station 953 at the top of Knight Chute at the bifurcation to the GM extension. (Photo 8.) The structure has a single radial gate at the top of Knight Chute and four slide gates that control flow into GM extension. A constant head orifice (CHO) box has been added to control the downstream water level for two of the slide gates, but the district manager said it doesn't work very well. (At high flows the downstream gate is submerged and level inside the CHO box will vary as downstream canal level varies.) The radial gate is used to maintain the upstream water level and it passes the remainder of the flow down Knight Chute into GM-100 lateral to the J Lake site. Control equipment at the site automatically adjusts the radial gate to maintain the upstream water level and telemeters water level and gate position data to GID headquarters via telephone lines.

**4.7 J Wasteway and J Lake site** - A small pond exists at the bifurcation to J Wasteway and the GM-100 lateral continuation, which is the intended site for J Lake. (Photo 9.) A check structure with three slide gates controls the flow to GM-100 lateral. Water enters J

Wasteway via a separate overflow structure (stoplogs) and is measured at a Parshall Flume and telemetered to GID headquarters. The two check structures at the bifurcation would be replaced by outlets from J Lake. During our site visit, the canal system was flowing at maximum capacity and the flow through J Wasteway was virtually zero.

**4.8 GSC Check 1** - The first check structure in GSC is a short distance downstream from the headworks. (Photo 10.) Two Armtec overshot gates are controlled by a Modicon controller to automatically maintain the upstream water level. This site appears to be adequate as is. Because of the small pool upstream and the desire to keep a constant level for upstream turnouts, this is not a good site to vary the upstream water level in order to manage flows or water volumes.

**4.9 GSC Check 2 (Johnson Drop)** - The second check in GSC is at the bifurcation to Mill Coulee Canal (MCC) and Johnson Drop. (Photo 11 and 12.) The structure has a single radial gate at the top of Johnson Drop and four stop log bays as the MCC headworks. The radial gate is used to control the upstream water level in order to divert the desired flow into MCC. The remainder of the flow goes down Johnson Drop into the continuation of GSC. MCC flow is measured at a rated section about 100 ft downstream from the headworks. Control equipment at the site monitors upstream level and radial gate position and telemeters these data to GID headquarters. This equipment was intended to include local automatic control of the radial gate to maintain a constant upstream level, but that capability is not operable.

## 5.0 RECOMMENDED OPERATIONS

System enhancements will allow GID to improve canal operations. The status of project infrastructure will determine which operating techniques are best. Regardless of the techniques used, the primary goals of operations should be:

- Accurate and dependable deliveries to water users. Users should receive their water in the correct quantity, rate, and duration.
- Minimize waste, especially that which flows to Muddy Creek.
- Minimize operating and maintenance costs.
- Simplify the canal operators' jobs.

**5.1 Operations Without J Lake** - Without J Lake, canal system operations should emphasize:

a) matching inflow (supply) to outflow (demand);
b) quick response to flow changes;
c) use of in-channel storage;
d) diverting excess flows into the Sun River drainage instead of the Muddy Creek drainage.

These items will require changes in operating philosophy as well as improved control capabilities. Check structures can be used to improve system response and recovery time and to manage in-channel storage volumes. Instead of routing each flow change from head end to tail end over a 36-hour period, flows could be changed quickly at all checks. Some of the water now wasted could be saved in the canal. Perhaps the easiest and most effective way to do this is by using a simultaneous gate operating technique. In a canal system with supervisory control capabilities, operators can adjust the flow at all check structures at the same time. A new flow rate can be established quickly without waiting for a large volume of water to drain or fill.

Another possible change in philosophy relates to the management of excess flows. Presently, excess water is directed towards J Wasteway. Surplus flows could instead be directed away from GMC and GSC by increasing diversions into Big Coulee Canal, Big Coulee Wasteway, and Mill Coulee Canal. This strategy should only be used if these diversions don't create more problems than benefits.

These changes in operating technique are more easily said than done, but they are valid considerations for long-term improvement in system performance. Similar techniques are being used successfully on many other canals.

**5.2 Operations With J Lake** - With J Lake, operations should emphasize:

a) relatively steady flow in the canal from Pishkun Reservoir to J Lake using an upstream (supply-oriented) operating concept and upstream level control at check structures;
b) periodic adjustments to canal headworks flow based on the water level in J Lake;
c) downstream (demand-oriented) operating concept in GM-100 Canal below J Lake, with releases from J Lake into GM-100 Canal matching downstream demand;
d) diverting excess flows towards J Lake;
e) maintaining enough water in J Lake to avoid tailender shortages in GM-100 Canal, but saving most of the lake's capacity to accumulate excess water during rapid flow reductions.

The regulatory storage provided by J Lake will improve canal operations without significant changes in operating philosophy from the way GID has traditionally managed the system. Releases from Pishkun Reservoir can be based on delivery schedules and intermediate check structures can be operated to maintain the upstream water level while diverting excess flows to J Lake. However, if some water is kept in J Lake to supply GM-100 Canal for short periods when demand exceeds expectations, headworks flow shouldn't need to include a surplus to prevent shorting the tailenders.

J Lake will have a finite capacity to absorb and supply flow changes in the canal system. When an event occurs that exceeds this capacity, operations personnel can use the techniques discussed in section 5.1 to manage the system. Essentially, once J Lake is full during a system flow reduction or empty during a flow increase, the system will need to be operated as if J Lake did not exist. Therefore, additional control system enhancements will still be valuable after J Lake is constructed.

## 6.0 FEASIBILITY

**6.1 Monitoring** - The best benefits to cost ratio is likely to come from improved monitoring at GID headquarters of key water level and gate position data. Existing monitoring on the project appears to be quite valuable. Data collection equipment usually can be furnished for a few thousand dollars per site. If the existing communication system and master station equipment allows for easy expansion, additional monitoring sites can be added for relatively little expense. Including installation, testing, and technical support, a cost of $5000 to $10,000 per site is reasonable.

**6.2 Supervisory Control** - The cost to remotely control check gates is largely dependent on the existing infrastructure. For a structure that already has power and motorized gates, such as SRS-71 Check, remote control should only add a few thousand dollars over the cost of monitoring. Most of this expense is to assure safe operations. Gate limit switches, alarm software, and thorough interface with gate actuators are important when no one will be at the site to observe any problems that can develop. Costs will rise if onsite monitoring equipment (RTU) doesn't have sufficient capacity for complete control functions. Also, additional master station software may be required. Supervisory control may add from $1000 to $10,000 per site, depending on the existing monitoring system. This cost does not include structural modifications.

Benefits can be substantial, but are difficult to quantify. Tangible benefits include reduced labor and reduced mileage on GID vehicles. The greatest benefit will be improved system operation through better management of flows and water levels, enabling some of the operating techniques discussed above. On many existing canals, damage prevented by the quick response to a single emergency event has more than paid for control system costs.

**6.3 Local Automatic Control** - Most of the cost for automatic feedback control is in the development, testing, and calibration of the control algorithm and associated local control software. This algorithm is the logic that determines exact gate adjustments. Automatic control opens the door for "Murphy's Law" problems, so it pays to do the job well from the start. At least $5000 per site should be budgeted. Onsite controllers (RTU) must have enough memory and intelligence for the local control software. Benefits stem mostly from reduced labor and better water level control.

**6.4 J Lake** - The J Lake proposal discussed above estimates a cost of approximately one million dollars to construct the reservoir. This is an order of magnitude greater than canal automation features, but J Lake will provide long-term benefits and service. The cost of J Lake should be weighed against other long-term remediation measures. J Lake should compliment current Muddy Creek restoration activities and reduce future expenses.

## 7.0 SUBSURFACE DRAINAGE

It appears that a substantial portion of the water entering Muddy Creek comes from subsurface drainage rather than surface drains and wasteways. Therefore, long-term planning should address the reduction of all excess drainage, not just wasteway flows. Excess water applied to farm fields may have the same effect as waste flow into the coulees. Requiring irrigators to wait 24 hours before shutting off their turnout may reduce flow in J Wasteway but not in Muddy Creek, as the excess water not used by crops travels via groundwater into Muddy Creek anyway.

Eliminating the bulk of the drainage flows may require substantial on-farm improvements, such as replacing flood irrigation with sprinklers. However, subsurface drainage could be reduced through more accurate and flexible deliveries to water users. If the canal system can respond more quickly to flow changes, GID will be able to provide a better water supply to irrigators. The resulting improvements in on-farm irrigation practices will reduce drainage flows entering Muddy Creek while increasing farm productivity.

## 8.0 CONCLUSIONS

The recommended priority of actions to improve canal operations is as follows:

1. Fix or upgrade the existing data collection system and local automatic controllers.
2. Add data collection and monitoring capabilities to key sites.
3. Add supervisory manual control to existing sites that do not require substantial infrastructure modifications.
4. Construct J Lake and use it instead of J Wasteway.
5. Develop operating techniques that take advantage of monitoring and remote control capabilities to better manage the movement of water within the system. Start to use in-channel storage and simultaneous gate operation. Divert excess flows into branches that waste into the Sun River instead of Muddy Creek.
6. Upgrade or add check structures with monitoring and remote manual control. Use these structures to expand the operations in step 5 above.

Modernization decisions must take intangible benefits and costs into account. Intangibles are important, maybe more important than tangible benefits and costs. Technical feasibility establishes what *can* be done, but not what *will* be done with system modifications. A feature like J Lake will be used advantageously by the district, because it fits well with their existing methods of operation. More complicated schemes that require major changes in the district's operating methods may be less successful.

Report prepared by:

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Bureau of Reclamation, D-8560
Technical Service Center, Denver, Colorado
August 6, 1996

Photo 1 - SRS-71 Check (check #1)

Photo 2 - SVC Headgate (check #2)

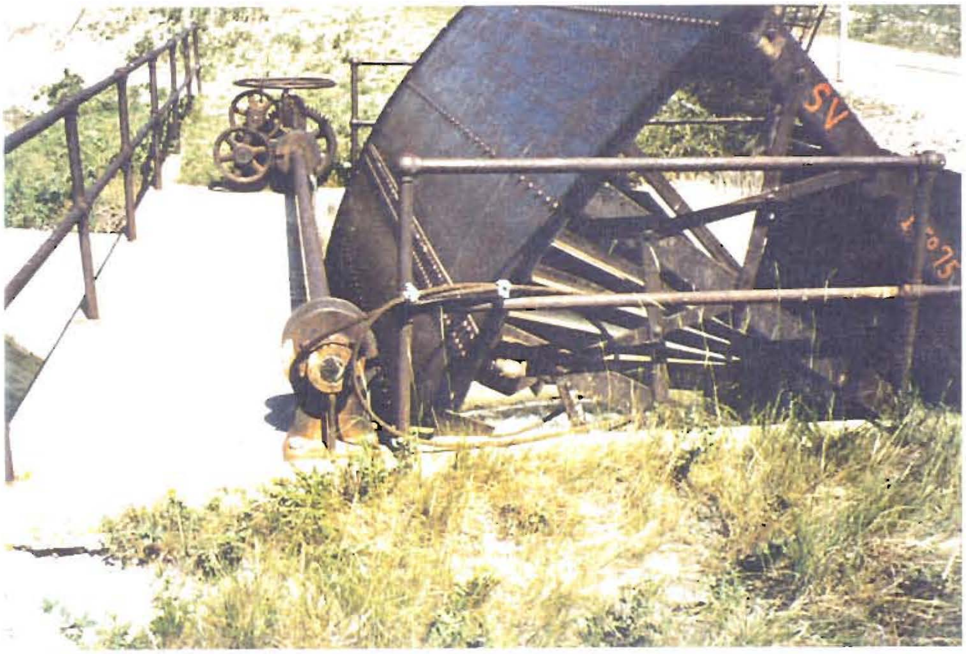



Photo 3 - Radial gate at check #2 (SVC Headgate)

Photo 4 - SVC-35 Check (check #3)

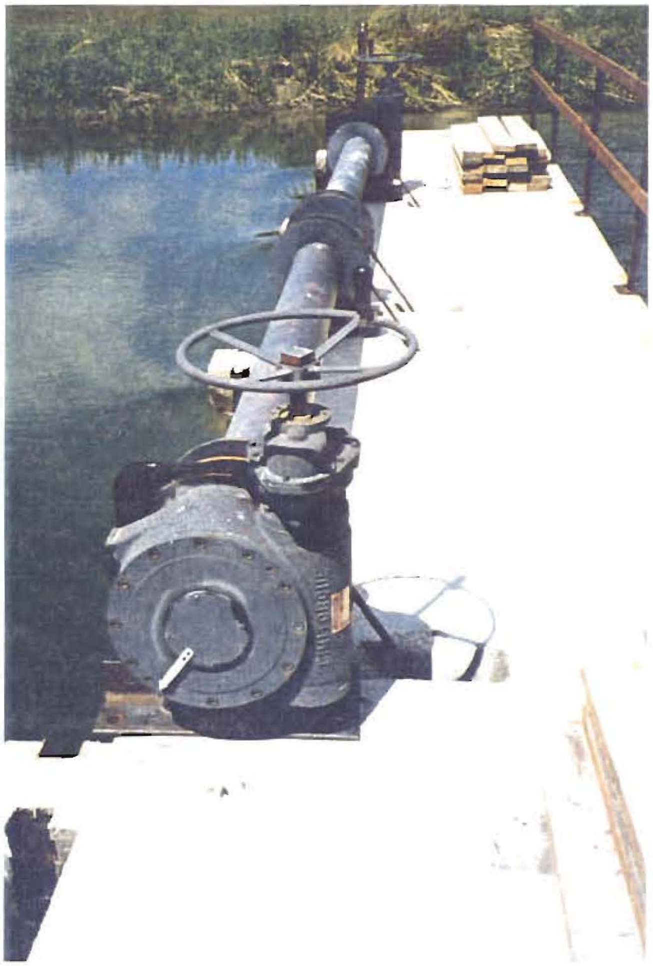


Photo 5 - Double overshot gate hoists at check #3 (SVC-35 Check)

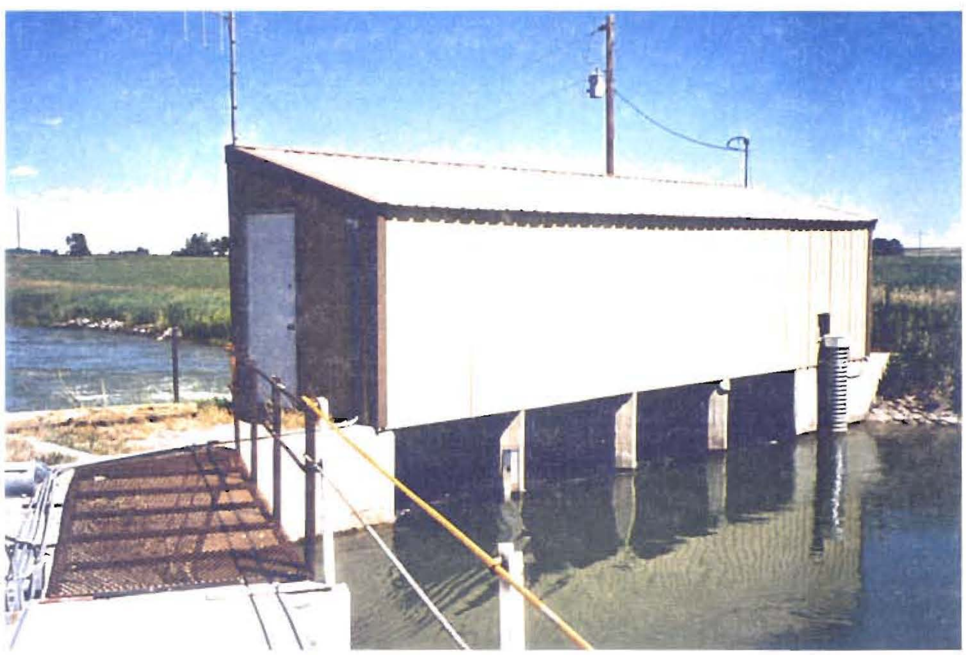


Photo 6 - GMC-57 Check (Mary Taylor Drop), GSC headgates

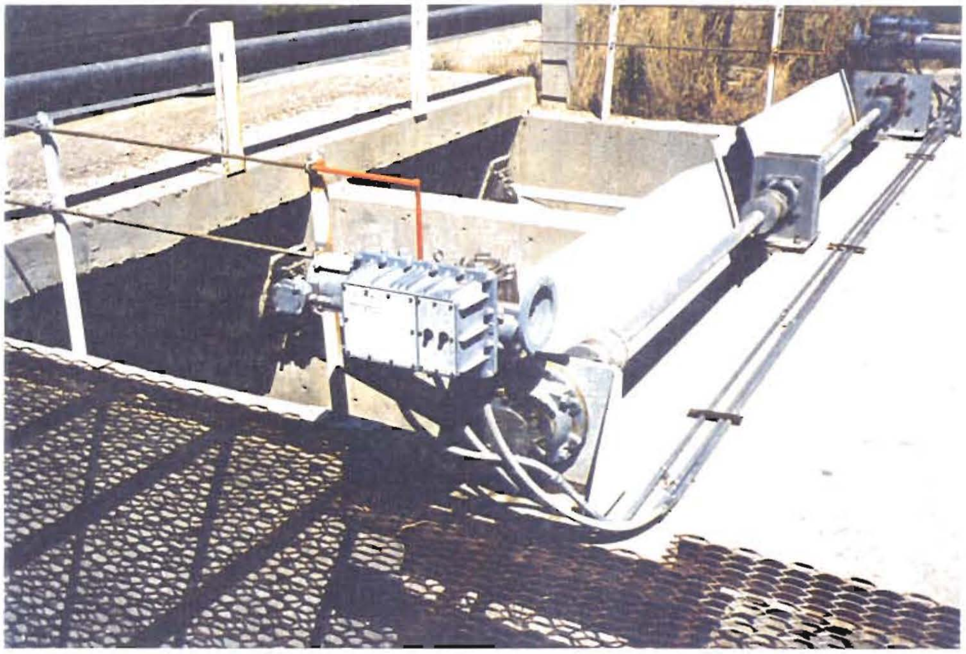


Photo 7 - Radial gates at GMC-57 Check (Mary Taylor Drop)

Photo 8 - GMC-95 Check (Knight Chute)

Photo 9 - J Lake site with existing check structure and J Wasteway

Photo 10 - GSC Check 1

Photo 11 - GSC Check 2 (Johnson Drop), MCC headworks

Photo 12 - Radial gate at inlet to Johnson Drop (GSC Check 2)

# Rubicon Water Scoping Study

## Greenfields Irrigation District

# Main Canal

January 2016

# 1. Executive Summary

Greenfields Irrigation District (GID) is looking for options to modernize its infrastructure to improve overall customer service and operating efficiencies. The long travel times in the main canal can result in significant spill, despite the best efforts of the operators. This operational spill can be reduced by using precise real-time flow controllers at key structures to enable the main canal to provide in-system storage to capture water within the system when diversions are reduced from Pishkun Reservoir in response to reduced demand.

Rubicon Water supplies mature and proven technology to eliminate operational spills in open canal networks by precisely matching supplied flows to demand. Rubicon's Network Control solutions have been in operation for more than thirteen years and are helping many districts worldwide to improve distribution efficiency by precisely matching supplied flows to demand at all points through the network. It has been identified that Rubicon's approach to eliminating system spills can be applied to Greenfield's Main Canal, and this report details Rubicon's approach and presents a proposed solution.

Rubicon's flow control solutions will enable Greenfields Irrigation District to match the water supplied within the main canal to aggregate demand in real time and will continually regulate the reservoir headworks and main canal regulating structures to maintain a constant volume of water in the main canal independent of demand fluctuations. This will reduce the return flows to the Sun River via Muddy Creek and other tributaries and result in significant water savings and environmental benefits. It is believed that the spills from the main canal can be greatly reduced under normal conditions, saving up to 20,000 acre feet of water per year.

A phased implementation is proposed, with an estimated build out price of $1,549,752 for automation of the main canal. This investment in Rubicon's solution will reduce spill from the Main Canal by precisely matching supply with demand. Operational spills will be eliminated leaving more water in storage for later availability to farmers and allowing less water to be diverted from the Sun River. The volume of water historically lost from operational spills can be retained in storage, reducing the required diversions from the Sun River and making more water available to irrigators in dry years.

# 3. Background

## 3.1 Greenfields Irrigation District

The Greenfields Irrigation District (GID) is located northwest of Great Falls, Montana. Agriculture is the main source of income in the area. GID supplies water to about 800 water users occupying 83,000 acres of elevated bench land. The main irrigated area is about 15 miles long and 8 miles wide. Main crops grown are Barley and Malt. There are also alfalfa hay pastures, corn and a few exotic crops such as peas and mint.

GID is a Division of the Sun River Project which also encompasses Fort Shaw Division and Upper Missouri Projects. The delivery network was constructed by the BOR and first delivered water in 1920. Water is transported from the Sun River to the Greenfields Irrigation District via two storage reservoirs and about 70 miles of waterways. Snow from the Rockies goes into storage at Gibson Reservoir which includes Greenfield's primary storage of 98,000 acre feet. An open canal, which also includes tunnels, takes water to the Pishkun Reservoir.

From Pishkun a diversion supplies GID's main supply canal at a maximum flow of 1,700 cfs. The main canal system is 59 miles long. The width of this main canal is approximately 80 - 100ft.

GID diverts about 230,000 acre-feet annually. GID processes water orders when received, schedules flows to the area of need, and delivers the flows to each individual farm unit. The District's customers are billed per acre. Water users must order 48 hours in advance. The order shut-off time is 8-12 hours. Water orders are processed by a central computer which adds up the total orders and calculates water rationing. Demand often exceeds capacity and ditch riders get involved in trying to negotiate with the water users to get necessary rations to the right places.

The normal assessment is 2 acre feet per acre. In normal precipitation years Greenfields Irrigation District has sufficient water for its users. During the 2015 irrigation season however, customers were rationed to 1.5 acre feet due to a water shortage of approximately 30,000 acre feet, and deliveries were shut down in August (one month early).

Water not consumed by crops returns to the Sun River via several main tributaries. The long response time from source to delivery creates a water regulation problem which contributes to sporadic flows to wasteway channels. It takes about 40 hours for a physical change in flow to pass through the system. While changes at the headwork diversion pass through the system, any overage will merely pass through wasteway channels. The most significant return channel is Muddy Creek, a channel draining 50,000 acres of irrigated land which is eroding severely. Approximately 70,000 acre feet of GID's diversion returns to the Sun River via the Muddy Creek drainage. Another 22,000 acre-feet returns to the Sun River via other wasteways.

Several studies have been conducted by the District to identify methods to physically reduce flows to the eroding Muddy Creek and Mill Coulee Creek near Sun River. Proposals have included the installation of control structures in the main canal system to retain flow during canal surplus periods. It has been proposed that these projects would have significant public benefit – reducing sediment transport from Muddy and Mill Coulee Creeks by 10,000 – 15,000 tonnes annually.

The District has expressed interested in Rubicon's technology for the following reasons:

- Additional storage in the main canal would put GID in better shape during drought years when the district is approximately 30,000 acre feet short
- Better control will improve delivery during rationing
- Improved reaction times during extraordinary events such as rainstorms when it is fairly common to have a loss of power supply, sometimes for 4 or 5 hours
- Reduce water loss to improve delivery during drought years or to be able to return more water to the Sun River, from which GID water is drawn - thus satisfying the needs of other stakeholders.

It has been proposed that the above improvements could be made by automating the main canal which runs from the Pishkin Reservoir approximately 35 miles until it splits to the main laterals at the City of Fairfield.

## 3.2 Rubicon Water

Rubicon Water provides advanced technology to managers of gravity fed irrigation networks that enables them to operate and manage their water resources to unprecedented levels of efficiency and control.

## 3.4 Rubicon's Approach to Saving Water

Modernized irrigation supply systems offer a tremendous opportunity to recover water lost in off-farm distribution networks.

The primary purpose of an open canal irrigation system is to accurately deliver on-demand water to farmers at consistent requested flow rates. Even with a highly skilled and trained workforce, efficient on-demand operation of canals is a big challenge. Unpredictable water levels and potential shortages of water can occur. To ensure that the requested flow rates are delivered to farmers, canals are generally operated by supplying excess water from the head-works to ensure supply to farmers. This approach often results in operational spills which limit the availability of water for crop production or other beneficial use.

With an increasing focus on system operations efficiency, there is a growing awareness of the importance of eliminating canal and farm spill, whilst at the same time improving service levels to farmers.

Rubicon's Network Control provides a pathway to high system efficiencies by creating a near on-demand canal network that precisely controls the delivery of water from the supply reservoir through to each farmer's turnout. Water deliveries can be matched to farmers' requirements, reducing over-supply and reserving more water in storage for use later in the growing season. At the same time, water levels at the turnouts remain constant throughout the irrigation season, improving service levels to farmers.

Rubicon's Network Control solutions have been conserving vast amounts of water for irrigation districts for more than thirteen years. Our highly responsive near on demand supply systems provide managed constant flow rates to the farm while at the same time eliminating operational spills. These systems improve distribution efficiency by up to 30% to make additional water available for use late season when crops need it or to be 'banked' for future dry years.

And improved levels of service better position farmers to make precise irrigation management decisions, so that their crops receive the water they need, when they need it at the rate they need it, avoiding wastage and fertilizer runoff. This allows additional crop yield per acre foot of water applied.

## 3.6 Benefits Provided by Network Control

Network Control implementations have been delivering benefits for more than thirteen years to irrigation districts around the world. These benefits are summarized below:

- **Water Savings**
  - Canal system spills are effectively eliminated while delivering significantly improved customer service, improved system control and flexibility.
  - The resultant “on demand” service combined with assured flow rates onto farm facilitates on-farm savings and improvements.
  - The system provides distribution efficiency increases of the order of 25-30%, with 95% distribution efficiency being realised in districts such as the Coleambally Irrigation District (described further in the solution case examples below).

- **Improved customer service**
  - Close to “on-demand” supply to customers.
  - Supply of flow at the precise rate and quantity ordered.
  - Automated opening and closing of turnouts when SlipMeters are installed.
  - Orders are confirmed at the time of placement.
  - Ability to interface to on farm automation equipment to closely coordinate on-farm activities with water deliveries.

- **Productivity Savings**
  - Network Control systems operate automatically with less involvement from water operators, allowing them to focus on more high value activities
  - The Water Operator’s role changes from routine scheduling to supervision, exception handling, preventative maintenance and emergency response

- **Occupational Safety and Health Administration (OSHA)**
  - The Network Control system eliminates the manual lifting of drop boards and operation of manual structures

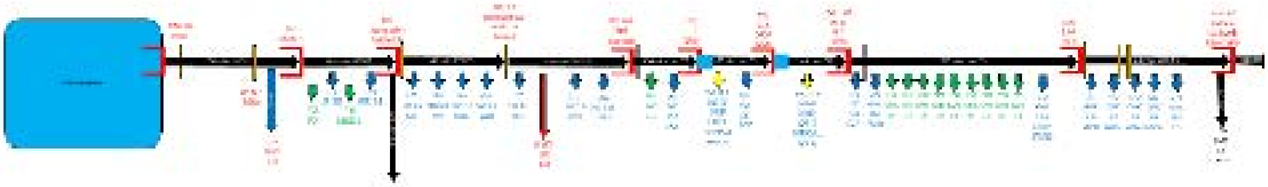


Figure 3 - Schematic Overview of the Main Canal

This schematic is enlarged in Figure 4 through Figure 9

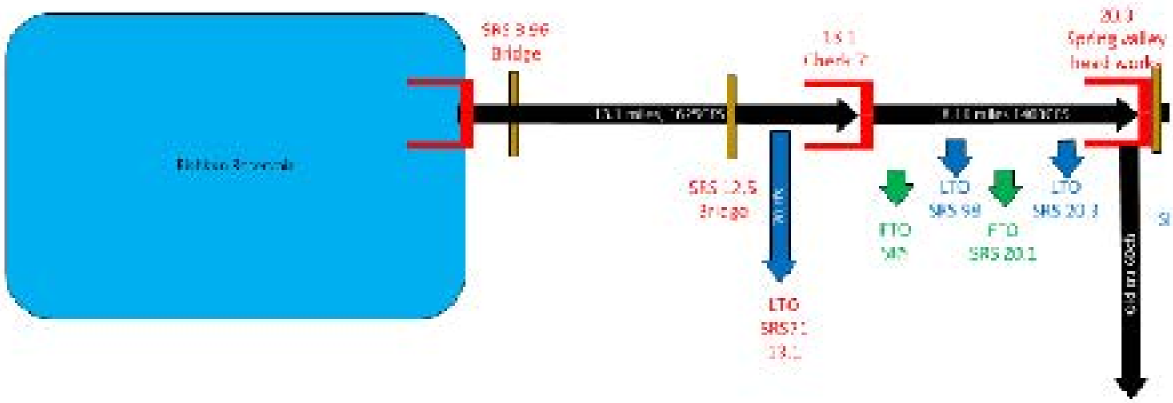



Figure 4 - Schematic of Main Canal – Pishkun Reservoir to Spring Valley Headworks

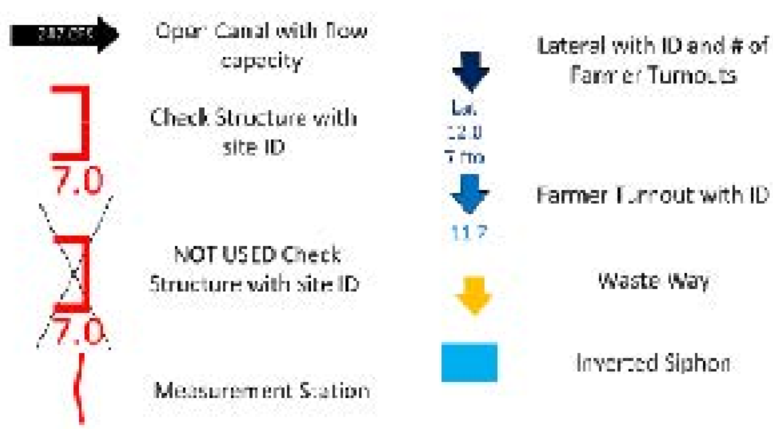



Figure 5 Schematic Symbols

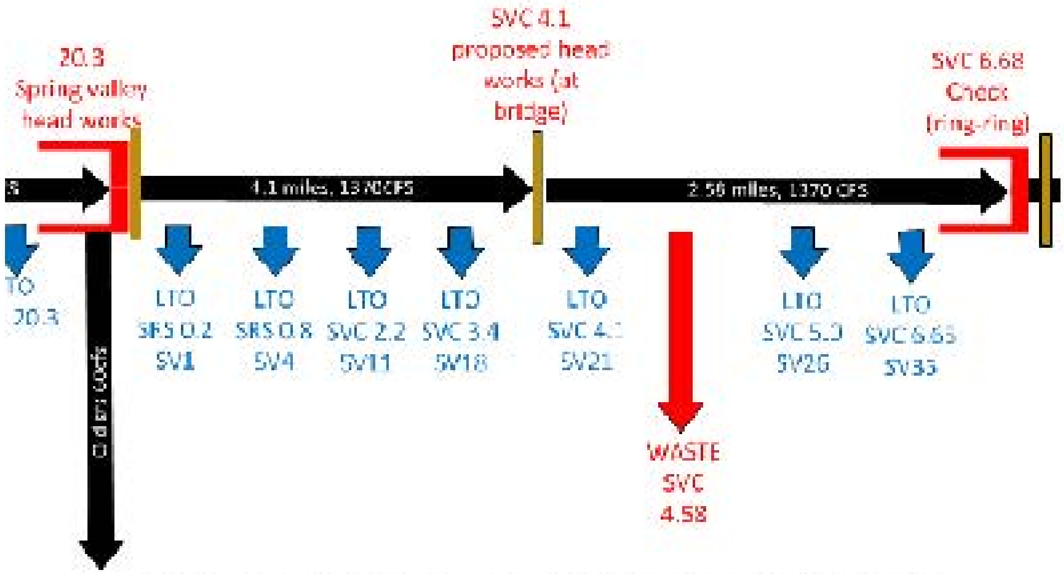



Figure 6 - Schematic of Main Canal - Spring Valley Headworks to Ring Ring Regulator

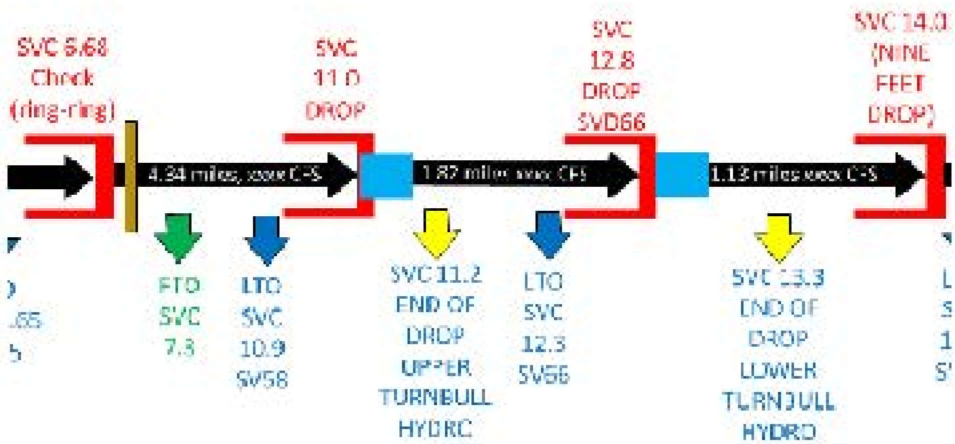



Figure 7 - Main Canal – Ring-Ring Regulator to Nine Feet Drop

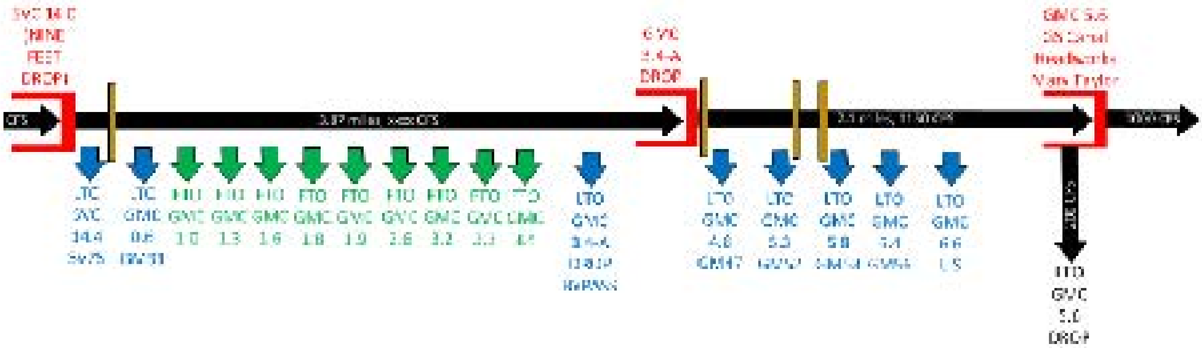


Figure 8 - Main Canal – Nine Feet Drop to Mary Taylor

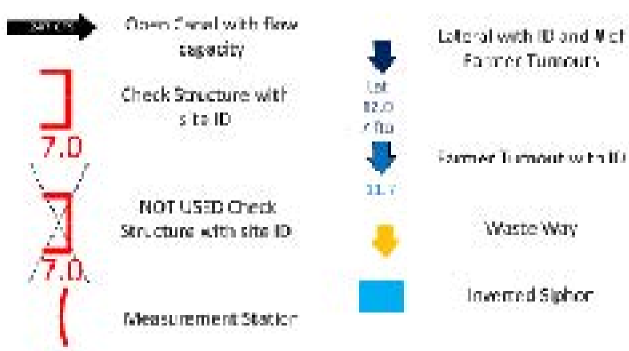



Figure 9 - Schematic Symbols

### 5.1.1 System Operations and Flow Capacities

The canal is presently operated in a supply driven mode where the flow is set at the top of the system and downstream structures are adjusted to maintain water levels.

The designed flow capacity is 1,700 cfs maximum out of Pishkun Reservoir. The capacity decreases along the length of the canal, with the following capacities provided by District staff:

- 1,625 cfs–1,575 cfs at the SRS12.5 bridge
- 1,400 cfs at the Spring Valley Headworks with 60 cfs diverted down the old SRS pipeline
- 1,250 cfs to 1,370 cfs at the Old Loop Spillway Waste
- 1,150 cfs at A Drop
- 1,000 cfs at Mary Taylor

The first check structure on the main supply canal is SRS 71 at Division 9. It has been proposed that additional checks could be put between the headworks and the first check to increase the storage capacity of this section of the canal.

The second check is at Spring Valley (called Spring Valley Check) where the main canal changes name to Spring Valley (SV) Canal.

There is a bottleneck around Divisions 1 and 2 where the canal goes into a 'loop' and flow is reduced to approximately 1370 cfs.

The third check is Ring Ring at mile mark 6.68 on the Spring Valley Canal.

There are 2 hydro-electric power stations in Division 8 producing 15 MW total on the main canal which are operated by an independent third party. The third party has no say in the canal operation. The inflow to the power plants is controlled by the power station operator.

Downstream of the power stations there is approximately 3ft of freeboard. The canal then passes down a 9ft drop into a lower section of canal. The flow at this point is approximately 1100 cfs.

### 5.1.2 Existing Check Structure Information

The following check structure information was obtained from Morrison Maierle, Inc.'s 2010 Technical Memorandum on Greenfields Irrigation District Main Canal Storage.

TABLE 1-1
Canal Geometry

| | Check # 71 | Spring Valley Headworks | | West Division Bridge | Ring-Ring Check |
|---|---|---|---|---|---|
| | | 1937 Design Drawings[1] | SRWG Seepage Study[2] | | |
| Bottom width (b) | 56 | 46 | 40 | 45 | 45 |
| Side slope (m) | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Normal depth (ft) | 8 | 9 | 9 | 8 | 8 |
| Normal Q (cfs) | 1600 | 1600 | 1500 | 1300 | 1300 |
| Slope (S) (ft/ft) | 0.00019 | 0.00019 | 0.000358 | 0.00033 | 0.00033 |
| Additional Check (ft) | 4 | 5 | 5 | 4 | 3 |

1) Sun River Slope Canal profile and sections (1937)
2) SRWG Seepage Study (TD&H, 2008)

Table 1 - Structure Size and Flow Rate Information

# 6. Proposed Approach

A typical canal modernization project is generally implemented in phases, and discussion with the District during the preparation of this report has established that a phased approach would be desirable to Greenfields Irrigation District.

The phases of implementation include:

1. Upgrade of inline check structures with water-tight precision flow control gates
2. The installation of a radio telemetry network and SCADA software to allow the remote operation and control of these gates
3. The tuning of controllers to allow these gates to cooperate to match supplied flow to downstream demand through the system
4. The automation of lateral offtakes to improve operations on the laterals
5. The measurement (and control) of farm turnouts

This implementation proposal for Greenfields Irrigation District focuses on Phases 1-3 listed above. Later phases may be added as desired in the future.

The implementation of the first three phases will allow GID to reduce operational spill by utilising the main canal pools for in-system storage.

The use of the main canal pools as in-system storage is achieved by continuous adjustment of the check structure control gates to maintain a constant volume of water in each pool as flow demand varies.

For safe operations without canal over-toppings, backwater effects need to be considered in each pool, and the transfer of water that occurs when a canal flow is reduced from maximum flow to zero flow needs to be considered.

The hydraulic behaviour of the pool as flow is increased and decreased is illustrated in Figure 10 overleaf.

This diagram shows a single pool in the main canal. This pool is bounded by its upstream and downstream regulating structures, which are shown as solid black lines at the top and bottom of the pool.

The typical operating strategy is to maintain a water level above the downstream regulator at a constant setpoint value.

When there is zero flow through the pool, the water level behind the upstream regulator is equal to the water level in front of the downstream regulator. This is shown in the first image in Figure 10. As the flow through the pool is increased, extra volume is added at the top of the pool to create the required energy grade line for higher flows. This volume builds up as a wedge along the length of the pool, indicated by the wedge in the second image in Figure 10.

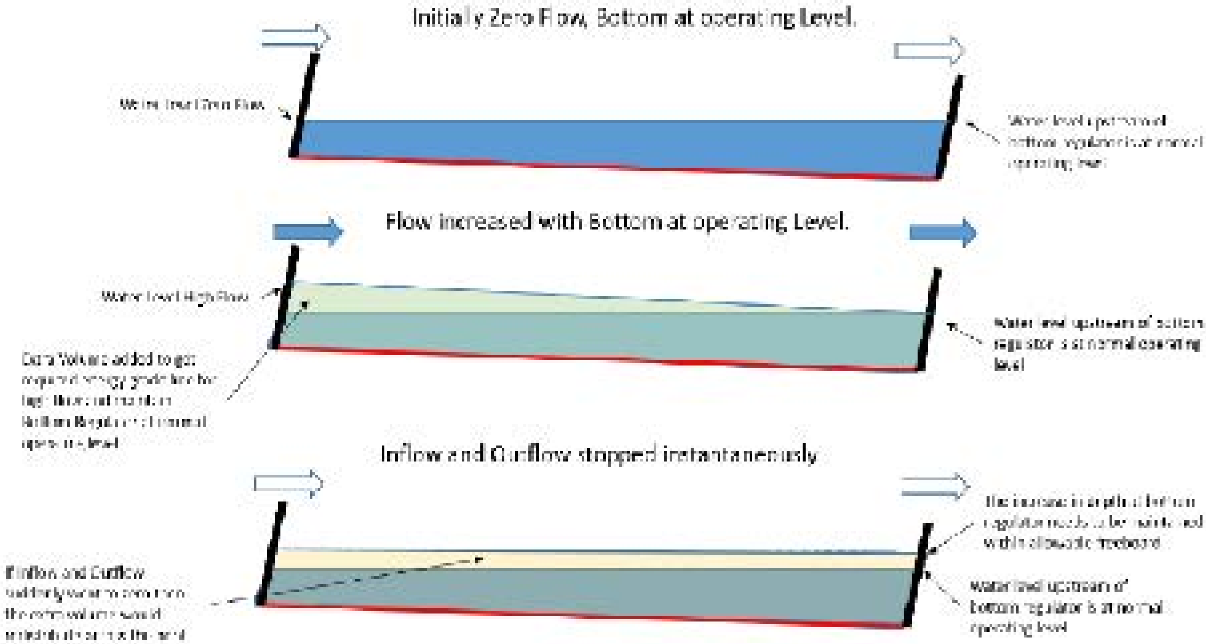



Figure 10: Managing constant pool volumes to eliminate spill

Under maximum flow conditions the water surface follows a gradient that approximately matches the bed slope of the canal.

When canal inflow and outflow are reduced to zero by instantaneously closing both the upstream and the downstream regulating structures, the continued flow throughout the length of the pool causes a transfer of volume from the top end of the pool to the bottom end of the pool. This ultimately results in a horizontal water surface and zero velocity and flow throughout the pool. This transfer of volume within the pool will cause the water level at the downstream end of the pool to rise, and this rise in water level must be carefully managed to prevent over-topping of the canal.

Rubicon's controllers are designed to safely capture water in each pool as allowed by the maximum pool elevation in front of each check structure, and safely pass any additional volume that would exceed this maximum pool elevation further downstream.

Under normal operations each check structure operates to maintain a water level setpoint upstream of the next check structure by matching inflows to outflows in each pool. As outflows increase, the pool inflows are increased in real time. As outflows decrease, the pool inflows are decreased in real time. In the event of an immediate shut-down, the inflows will be immediately shut-off, with the above safety mechanism implemented to prevent canal overtopping.

## 6.1 STEP 1: Upgrade of inline check structure with water-tight precision flow control gates

The first step in Rubicon's proposal is to upgrade the inline check structure gates to create precision water tight control structures. The check structures which Rubicon proposes to upgrade are listed in Table 2. The existing structure information has been obtained from design data provided by GID. Based on this information, Rubicon understands that the existing structures have the characteristics listed below.

| Structure Name | Structure Location | Structure Flow Capacity (cfs) |
|---|---|---|
| Headworks | Pishkun Reservoir | 1,700 |
| Check 71 | MC 13.1 | 1,625 |
| Spring Valley Headworks | MC 20.3 | 1,400 |
| Ring Ring | SVC 6.68 | 1,370 |
| Upper Turnbull Hydro and Drop | SVC 11.0 | 1160cfs, Min 200 through hydro |
| Lower Turnbull Hydro and Drop | SVC 12.8 | 1160 cfs, Min 200 through hydro |
| Mary Taylor | GMC5.6 | 1,000 |

Table 2 Main Canal: Existing Check Structure Information

Upgrades to each of these check structures are proposed as follows. These improvements can be implemented as a single project in a single year or can be implemented as several projects over a longer implementation period.

### 6.1.1 Pishkun Headworks

The head works of the Main Canal is controlled by existing actuated undershot gates. Outflows are controlled by three 40" wide by 7' tall undershot gates in the gate house. These are deep gates, whose sills are located 38ft below the floor of the gate house. These gates are presently actuated, and it is proposed that Rubicon add upstream and downstream water level sensors to provide an approximate measure of outflow using a submerged orifice equation. The water level sensors would be installed along with gate opening sensors and an RTU to compute an approximate flow measurement and provide gate opening setpoints to maintain flow setpoints.

At the maximum flow rate of 1,700cfs with the three gates fully open to their stroke of 7ft, the USBR submerged orifice equation indicates a head differential of 25ft.

The communications to the headworks is via a dedicated phone line. It is proposed that the existing line modems be used to communicate with this site via this dedicated phone line – provided the line is in good condition to guarantee reliable communications.

Rubicon requires further opportunity to inspect this site to provide an accurate estimate of the cost to integrate this site into a Network Control solution, but for budgetary purposes it is assumed that this site upgrade would cost approximately $25,000 – $35,000 to be refined upon further site inspection.

**ESTIMATED PRICE = $25,000 - $35,000.**

### 6.1.2 Check 71

Check 71, contains existing radial gates and dropboard slots which will be replaced under this proposal.

Figure 11 - SBS 71 Check Structure

The existing structure contains two existing radial gates, six drop board windows, and two concrete check bays. The maximum flow through this structure is 1625 cfs.

The total cost for the proposed FlumeGate hardware for this site is $482,660.

In addition, the installation and commissioning labor cost for this site would be $15,000.

Adding the hardware and labor costs results in the following estimated cost to automate Check 71.

**ESTIMATED PRICE = $497,660.**

If a checking height greater than 7.3ft is required, then the gates can be installed on sills, or Rubicon can also price FGB-6 ½-9.5 FlumeGates, which provide a checking height of 9.5 feet.

Rubicon can also supply walkways to suit the new gates at a price of $1,954 per walkway. These walkways are further described in the pricing summary below.

### 6.1.3 Spring Valley Headworks

The existing gate at Spring Valley Headworks is a radial undershot gate with a width of 16ft and a depth of 10ft. The high water mark is 8' 6". The maximum flow passed through Spring Valley Headworks is 1,400 cfs.

Figure 17 : Spring Valley Headworks Check Structure

The following undershot gates are proposed for Spring Valley Headworks:

Note that these gates are all solar powered and completely self contained complete solutions, so there are no other hardware costs on top of these, other than any civil works that might be required.

The total cost for the proposed FlumeGate hardware for this site is $397,000.

In addition, the installation and commissioning labor cost for this site would be $6,000.

Adding the hardware and labor costs results in the following estimated cost to automate Ring Ring.

**ESTIMATED PRICE = $403,000.**

Rubicon can also supply walkways to suit the new gates at a price of $2,073 per walkway. These walkways are further described in the pricing summary below.

### 6.1.5 Upper Turnbull Hydro and Drop

The fourth check structure on the main canal is the Upper Turnbull Hydro and Drop.

The left intake (looking downstream) at Upper Turnbull is the intake to the HydroElectric Power Station, and this flows at around 950cfs. The right hand intake is the bypass back to the canal.

The hydroelectric power stations require a minimum of 200cfs. The inflow is controlled by wicker gates inside the turbine which are automatically controlled by the company that owns the power stations.

Figure 14 Upper Turnbull Drop and Hydro Power Station

Rubicon proposes to connect a Remote Telemetry Unit to interface to the existing gate actuation on this site to enable these gates to be controlled as part of the Network Control implementation. Rubicon proposes to supply an RTU, radio communications, upstream and downstream water level sensors, and coding to interface into the existing actuation control devices.

This Remote Telemetry Unit will communicate to the office via a 450MHz licensed radio, and will supply water level measurement information both upstream and downstream of each gate along with gate opening information so that the flows through each gate can be computed using the USBR orifice equation.

It is assumed that accurate gate opening sensors are already fitted to the gates.

Rubicon requires further opportunity to inspect this site to provide an accurate estimate of the cost to integrate this site into a Network Control solution, but for budgetary purposes it is assumed that this site upgrade would cost approximately $25,000 – to be refined upon further site inspection.

**ESTIMATED PRICE = $25,000.**

### 6.1.6 Lower Turnbull Hydro and Drop

The fifth check structure on the main canal is the Lower Turnbull Hydro and Drop.

The left intake (looking downstream) at Lower Turnbull is the intake to the HydroElectric Power Station, and this flows at around 950cfs. The right hand intake is the bypass back to the canal.

The hydroelectric power stations require a minimum of 200cfs. The inflow is controlled by wicker gates inside the turbine which are automatically controlled by the company that owns the power stations.

Figure 15 - Lower Turnbull Drop and Power Station

Rubicon proposes to connect a Remote Telemetry Unit to interface to the existing gate actuation on this site to enable these gates to be controlled as part of the Network Control Implementation. Rubicon proposes to supply an RTU, radio communications, upstream and downstream water level sensors, coding to interface into the existing actuation control devices.

This Remote Telemetry Unit will communicate to the office via a 450MHz licensed radio, and will supply water level measurement information both upstream and downstream of each gate along with gate opening information so that the flows through each gate can be computed using the USBR orifice equation.

It is assumed that accurate gate opening sensors are already fitted to the gates.

Rubicon requires further opportunity to inspect this site to provide an accurate estimate of the cost to integrate this site into a Network Control solution, but for budgetary purposes it is assumed that this site upgrade would cost approximately $25,000 – to be refined upon further site inspection.

**ESTIMATED PRICE = $25,000.**

### 6.1.7 Mary Taylor

The sixth check structure is near GMC station 576, at the bifurcation to Greenfields South Canal (GSC) and the Mary Taylor Drop.

The structure has two radial gates at the inlet to Mary Taylor Drop and four slide gates that serve as the GSC headworks. The four slide gates at the GSC headworks are each 4ft wide and have a 4ft opening.

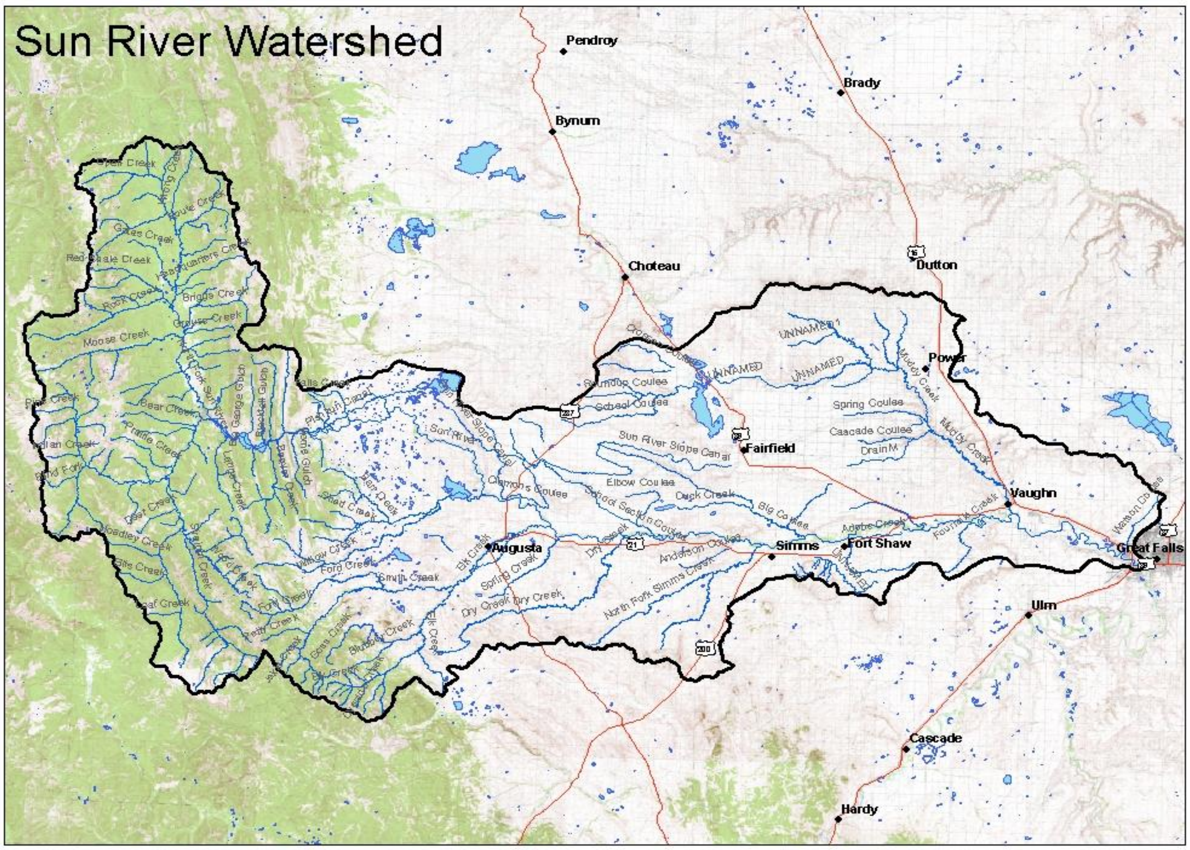
The radial gates control the upstream water level in order to divert the desired flow into GSC. The remainder of the flow goes down Mary Taylor Drop into the continuation of GMC.

GSC flow is measured at a rated section in the canal downstream. Control equipment at the site monitors upstream level and gate positions and telemeters these data via radio to GID headquarters.

The maximum flow passed through the four slide gates is 1,000 cfs.

Figure 16 - Mary Taylor Drop and GSC Headworks

# SUN RIVER WATERSHED GROUP SPECIAL STUDY REPORT





**Prepared by:**
**Sun River Watershed Group in Cooperation with the U.S. Department of Interior Bureau of Reclamation, and Montana Department of Natural Resources and Conservation**

**December, 2012**

U.S. DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

Sun River Watershed

MONTANA DNRC

MORRISON MAIERLE, INC.
An Employee-Owned Company

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# ACRONYMS

| | |
|---|---|
| BLM | U.S. Bureau of Land Management |
| DEQ | Montana Department of Environmental Quality |
| DNRC | Montana Department of Natural Resource and Conservation |
| FSID | Fort Shaw Irrigation District |
| FWP | Montana Department of Fish, Wildlife & Parks |
| GID | Greenfields Irrigation District |
| MSU | Montana State University |
| NRCS | U.S. Department of Agriculture Natural Resource Conservation Service |
| NRIS | Montana Natural Resource Information System |
| Project | The Sun River Irrigation Project |
| Reclamation | U.S. Bureau of Reclamation |
| SRWG | Sun River Watershed Group |
| TU | Trout Unlimited |
| USFS | U.S. Forest Service |
| USFWS | U.S. Fish & Wildlife Service |
| USGS | U.S. Geological Survey |

# Executive Summary

In 2009, Reclamation, in consultation with the Sun River Watershed Group (SWRG), initiated the Sun River Special Study. The Special Study is an inventory and analysis of proposed measures that could be implemented to improve streamflow in the Sun River while maintaining or improving irrigated agriculture production. The study identifies a procedure by which water savings can be allocated between improved streamflow in the Sun River and irrigation needs. Although the purpose of the Special Study was not to fund projects, it does identify steps that can be taken towards implementing projects.

The Special Study identifies potential projects that might save water and provide shared benefits to agriculture and instream flow. This includes projects identified in previous studies, and those brought forth during the Special Study. The potential projects identified were placed into four categories:

1. Those that improve delivery system efficiencies
2. Reservoirs, which would include new reservoirs or improvements to existing reservoirs
3. On-farm efficiency improvements
4. Other water management measures

Information was compiled on the identified projects and the projects with the best potential were compared and ranked. The ranking did not strictly order the projects from highest to lowest, but partitioned projects into three groups based on when it might realistically be possible to implement the projects. Group 1 projects were those that ranked high and which the group could pursue now or in the near future. The second group of potential projects consisted of those which the group considered to be good projects overall, but where there was a lot more work to be done before the projects could be implemented. The third group consisted of projects that might have some potential, but were complex, possibly expensive and not workable at this time, but could still be considered in future work planning.

The last section of the report outlines a plan for further evaluating and implementing the projects. Basic procedures that might be followed, from feasibility studies through project construction, are identified. Because every project is different, this implementation plan is general rather than project specific. An important component of any project selected would be to develop a plan for sharing the saved water between irrigation and instream uses.

This Special Study has identified a number of projects that have the potential to conserve water, and provide shared benefits to irrigators and instream flow in the Sun River. Although no one project will solve all of the low-flow problems in the watershed, taken together, these projects might be enough to produce shared benefits and to increase Sun River instream flows at key locations, and during critical times. Implementing these projects will require a commitment from group members and working together as a team to obtain the necessary funding for design, authorization, and construction. Continued success of the project will require follow-through with operation and maintenance long after the projects are constructed. Developing agreements among parties that allow for sharing a project's water-saving benefits between irrigation and instream uses will be critical to the success of these projects, and for achieving the goals of the Special Study.

The Special Study identifies projects and recommends a path for achieving the goals of improving Sun River flows and agricultural productivity. While the Special Study was in progress, the FSID and SRWG pursued an available opportunity to fund and implement a water conservation project with shared benefits. This project is presented in the report as an example of how future projects could be implemented to achieve Special Study goals.

# INTRODUCTION

## Special Study Background

In 2007, Reclamation, in consultation with the Sun River Watershed Group (SWRG), proposed to initiate a Special Study in Federal Fiscal Year 2009. Reclamation worked with the Sun River Watershed Group to define the specific objectives of the proposed Special Study. The study was funded by Reclamation and work began in early 2009.

Special Studies address a variety of activities that are required to make responsible resource management decisions, but not intended to lead to Federal actions requiring subsequent or additional authorizations by Congress. Special studies are usually undertaken with non-Federal entities to address specific problems or opportunities. Reclamation, as a participant, has an obligation to explore the Federal role in the study.

The expected outcomes of the Special Study were the identification of proposed measures that could be implemented to restore flows to the Sun River to address fisheries and other environmental concerns while maintaining or improving the irrigated agricultural economy of the area. The Special Study identifies measures that required appraisal level or feasibility studies to implement. The study also identifies measures that could be implemented with non-federal funds but involve Reclamation facilities, which may require an appropriate level of environmental and cultural resources compliance. An example of a potential measure that includes Reclamation facilities is a canal lining project where the appropriate share of the water savings is dedicated to in-stream flow needs.

The SRWG had been engaged for at least a decade in seeking an acceptable solution to the issue of enhancing the environmental health of the Sun River Watershed without negatively impacting irrigated agriculture, which includes the water supply available to irrigation. Part of this work includes previous studies and investigations on a broad range of topics that seek to describe the existing condition and various studies on potential projects. The SRWG had been successful in completing numerous watershed projects to date, and the Special Study would build on other ongoing efforts in the watershed.

This Special Study describes the existing state of the watershed, identifies key issues and concerns, and describes and recommends projects. Part of the initial work on the study was to assemble, review and summarize all relevant previously completed studies and projects. This was done to avoid duplicating work already completed. For potential projects where little or no existing information was available, preliminary investigations have been completed and summarized in the Special Study to identify potential costs, water savings, key issues and concerns, and to develop recommendations.

## The Sun River Basin

The Sun River Watershed is located east of the continental divide and south of Glacier National Park. It covers an area of 2,200 square miles (1,408,000 acres), with approximately 356 square miles (228,096 acres) in northwest Cascade County, 1,089 square miles (696,960 acres) in east Lewis & Clark County, and 755 square miles (482,944 acres) in southern Teton County. The Sun River starts at the confluence of the North and South Forks at Gibson Reservoir. Elevations in the headwaters in the Bob Marshall Wilderness area are as high as 9,000 feet. From Gibson Reservoir, the river meanders out of the mountains through rolling grass-covered foothills and farmland for 100 miles to its confluence with the Missouri River at the City of Great Falls at an elevation of about 1,800 feet. Along the way, the river passes through the communities of Augusta, Simms, Fort Shaw, Sun River, Vaughn, and Sun Prairie Village.

### *Ownership and land-use patterns*

The headwaters of the Sun River watershed are mostly in National Forest Lands. As the river leaves the Rocky Mountain Front, land ownership changes to primarily private. The first major irrigator is the Broken O Ranch, which has one of the largest irrigation land bases of all the ranches in Montana. The Greenfields Irrigation District (GID) is the largest single irrigation entity in the watershed, followed by the Fort Shaw Irrigation District (FSID). Other irrigation districts and private irrigators also use Sun River water. Table 1 summarizes land ownership and irrigation patterns in the watershed.

**Table 1. Land ownership and irrigated acreages in the Sun River Watershed (Acres).**

| | | |
|---|---|---|
| US Forest Service...................... | | 484,352 |
| MT State Lands.......................... | | 98,560 |
| Reclamation ................................ | | 17,920 |
| US Bureau of Land Management..... | | 5,120 |
| USFWS ................................ | | 160 |
| Irrigated Lands (Total) | | 117,700 |
| *GID* | *87,000* | |
| *Broken O Ranch* | *17,000* | |
| *FSID* | *10,000* | |
| *Sun River Ditch* | *3,200* | |
| *Rocky Reef Ditch* | *500* | |
| Urban.................................. | | 3,000 |
| Other Private property ........................ | | 799,048 |
| **Total Acres** | | **1,525,860** |

## The Sun River Watershed Group and its Organization

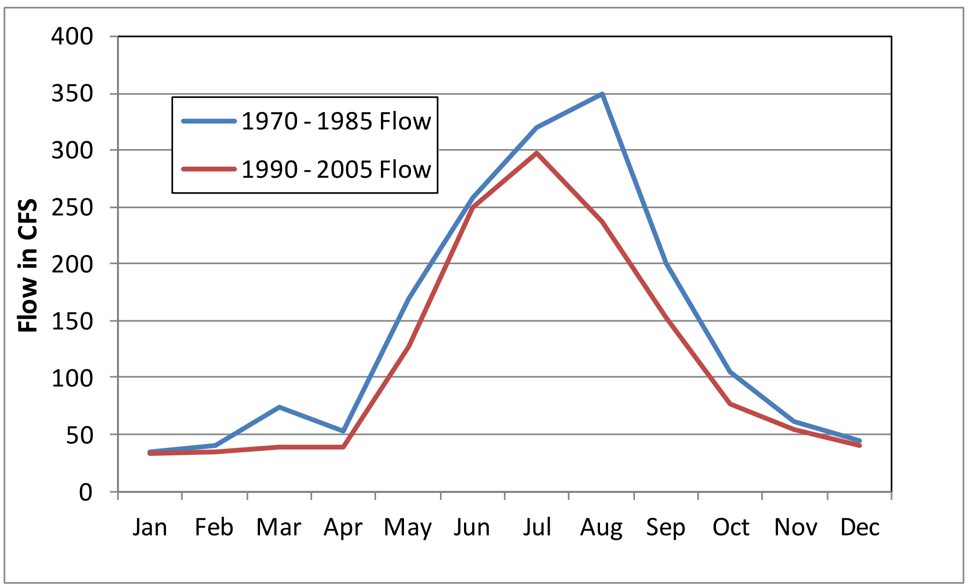
***General Description and Mission*** **-** The Sun River Watershed Group is a nonprofit organization that was formed to help resolve natural resource problems using a consensus-based approach. The multi-stakeholder group strives to promote community-based efforts that will preserve quality of life and livelihoods, while promoting and enhancing the natural resources of the watershed. Participation in the organization is open to anyone or any group that is willing to work through collaboration. The group is funded through contributions from participating groups, business contributions, individual contributions, and government and private grants.

***History and Accomplishments*** - Formed in 1994, the Sun River Watershed Group is the key to local involvement to resolve watershed natural resource issues, which include weeds, water quality and water quantity. In 1996 the SRWG officially formed as a 501 © (3) nonprofit organization to access additional funds to work on natural resource projects.

Historically, controversy was a way of life in the Sun River Basin, with battle lines drawn on the issues of water rights, erosion causes, water for fisheries and recreation, and water quality conditions. The tug-of-war began to change in 1994 when the Muddy Creek Task Force organized to break the status-quo and to provide a team approach to resolving one of the worst non-point source pollution problems in Montana. The group discovered innovative ways to tackle this problem which had stalemated for more than 30 years. From the beginning it was agreed that, once the Task Force had a good start, it would enlarge the boundaries and participation to encompass the entire Sun River watershed. In 1996, with the demonstration of the Muddy Creek success story, leaders in the basin felt it was time to expand efforts to the bigger watershed area. Soon, other success stories included the following:

- Elk Creek channel work to improve stream dynamics
- Willow Creek erosion control work to reduce high sediment loads entering Willow Creek Reservoir
- Mill Coulee channel work to improve stream dynamics and riparian health
- FSID water saving projects including conversion of open ditches to pipelines, canal lining and installation of measurement devices
- GID water savings projects including canal lining, conversion of open ditches to pipelines, wastewater pump-back systems, and installation of measurement devices
- The conversion of many flood irrigation systems to more efficient sprinkler systems
- A resulting reduction to irrigation and waste-water flows entering Muddy Creek (Figure 1) where high waste-water flows were causing serious erosion on that stream.

**Figure 1. Average Monthly Flow for Muddy Creek at Vaughn for periods before and after implementation of water conservation measures.**




***Structure*** **-** The Sun River Watershed Board is comprised of the officers of president, vice-president, secretary and treasurer, and of individuals who have a vested interest in the watershed. Formal decisions by the group and by-laws for the core organization are made by an executive committee comprised of individuals from Cascade Conservation District, Teton Conservation District, Lewis & Clark Conservation District, Muddy Creek Task Force chair, and member-at-large. The executive board makes day-today decisions and handles all financial responsibilities. The current executive committee is comprised of Fay Lesmeister (Cascade Conservation District), Brad DeZort (Teton Conservation District), Mike Cobb (Lewis and Clark Conservation District), Skip Neuman (Muddy Creek Task Force), and at large member Michael Konen.

The rest of the SRWG participants can be anyone and everyone. Federal, state, and local agencies and groups participating in the group include the U.S. Bureau of Reclamation (Reclamation), U.S. Fish & Wildlife Service (USFWS), U.S. Bureau of Land Management (BLM), U.S. Forest Service (USFS), Montana Department of

Environmental Quality (DEQ), Montana Department of Natural Resources and Conservation (DNRC), Montana Fish, Wildlife and Parks (FWP), Montana State University (MSU) Extension Service, and many individual landowners.

***Watershed Group:*** From scoping meetings and subsequent work meetings the Sun River Watershed Group objectives (in no particular order) are to:

1) Maintain and/or improve a viable agriculture economy
2) Control noxious weed infestations in the Sun River Watershed
3) Reduce the sediment loads into the Sun and Missouri Rivers
4) Improve the overall water quality of the Sun River
5) Improve the flows in the Sun River
6) Improve the fisheries of the Sun River

## Sun River Water Supply and Water Use

Most of the flow of the Sun River originates in the higher-elevation headwaters of the watershed in the Rocky Mountains west of Great Falls, Montana. The two primary tributaries are the North and the South Forks which join to form the Sun River at the head of Gibson Reservoir on the Rocky Mountain Front. These two streams produce runoff and consistent base flow, due to the higher precipitation and snow retention that occurs at the higher elevations in the mountains.

**Photo 1: The North Fork of the Sun River above Gibson Reservoir.**

Gibson Reservoir provides storage of the combined flow of the North and the South Forks of the Sun River. It has a capacity of about 96,477 acre-feet and is operated and maintained by GID in accordance with their contract with Reclamation. Reclamation provides oversight during spring runoff, while GID operates the reservoir during the irrigation season to meet irrigation demands on GID, while passing the water needed for senior irrigation water rights on the Sun River downstream. Water typically is stored in Gibson during two periods: following the irrigation season in the late fall and winter, and during the snowmelt-runoff period in the spring. Storage builds up slowly during the fall, winter and early spring, and quickly during snowmelt runoff in May and June. Typically the reservoir begins releasing stored water for irrigation demands starting from late May to early July, with storage releases beginning in June during most years. Releases continue until the early fall, when the reservoir typically reaches its lowest level.

Just downstream of Gibson Reservoir, the Sun River Diversion Dam diverts water through a 1,400 cfs capacity canal to Pishkun Reservoir, an off stream Reclamation Reservoir with an active storage capacity of about 30,686 acre-feet. From there, the water is reregulated and delivered to the Greenfields Irrigation District, which irrigates about 83,000 acres. Some of the water that is diverted from the Sun River at the Diversion Dam also goes to Willow Creek Reservoir, with an active storage capacity of about 31,847 acre-feet. Water from Willow Creek Reservoir is released back to the Sun River to ensure there is enough water in the river for senior users and for the Fort Shaw Irrigation District, which has some storage rights and irrigates about 10,000 acres. The main diversion dam for the FSID is located upstream of the town of Simms. The Broken O Ranch also irrigates a considerable acreage of land with Sun River water, which is diverted at several locations between the mouth of Willow Creek and the Fort Shaw Diversion Dam.

**Photo 2. Gibson Dam and Reservoir near the end of the irrigation season.**

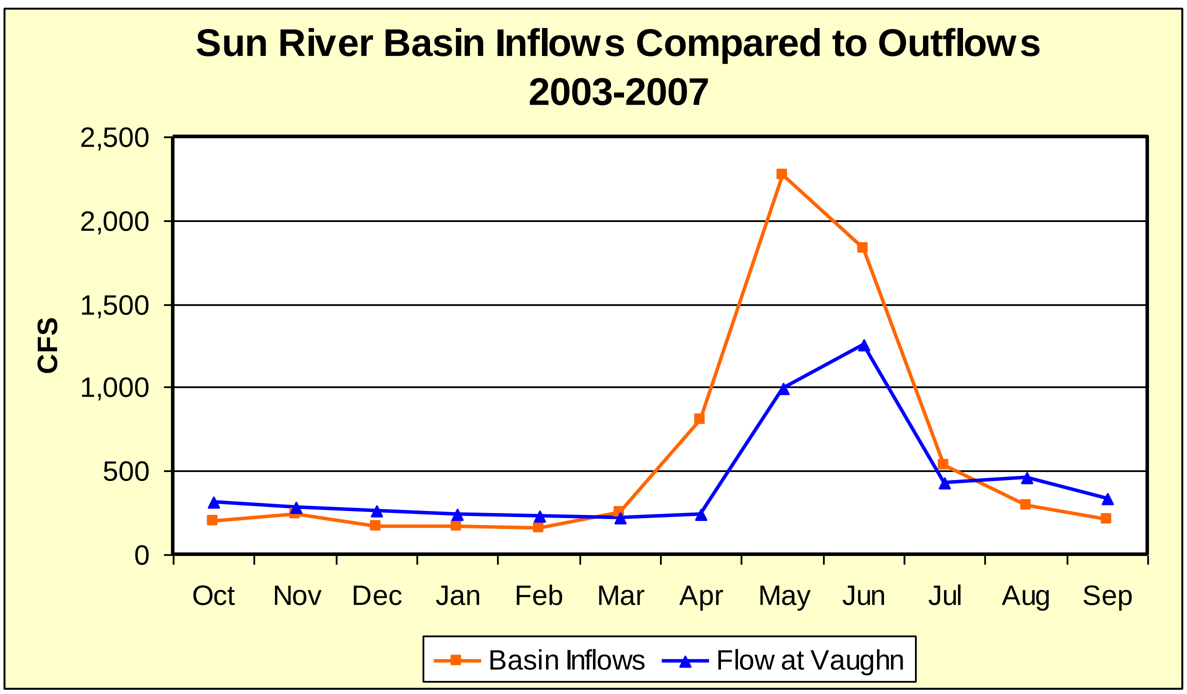
The inflow to Gibson Reservoir from the North and South Forks of the Sun River is by far the largest source of water in the basin. For the period from 1930 through 2007, about the time that the Special Study began, the average annual inflow was approximately 595,000 acre-feet. On average 85% of this water was produced during the April-through-September period, but a substantial amount of the winter inflow to Gibson Reservoir is stored for release during the following irrigation season. Elk Creek, the largest higher-elevation Sun River tributary, contributes about 5-to-10 percent of the total basin flow. Nilan Reservoir, a DNRC project with a capacity of about 10,000 acre-feet, stores and releases water from the Ford and Smith Creek tributaries for irrigation in the Elk Creek drainage.

The USGS, Reclamation, DNRC, and the SRWG all collect streamflow data in the watershed. These data are used to characterize basin water supply and water use. In addition to the Sun River proper, flow data are collected for a number of tributaries including Elk Creek, Big Coulee, Adobe Creek, Mill Coulee, and Muddy Creek. Map 1 depicts the locations of the gaging stations that are operated in the Sun River watershed, as well as the various reservoirs, main irrigation supply canals, and irrigation districts.

## *Water Supply for Irrigation*

Hydrologic data for a 5-year period (2003-2007) were used to characterize the limitations of the Sun River water supply in meeting irrigation demands. This 5-year period is representative of more recent drought conditions. The annual average inflow to Gibson Reservoir during 2003-2007 was 402,000 acre-feet, or approximately 190,000 acre-feet less than the long-term average. Figure 2 compares high elevation Sun River watershed inflows to Sun River outflows for the period. Total inflows include that from the North and South Forks of the Sun River, plus an additional component that flows in from around the Gibson Reservoir area. Total inflow also includes Elk Creek, which contributes to Sun River flows below the Diversion Dam. Outflows are from the Sun River at Vaughn gaging station, near where the Sun River joins the Missouri River.

**Figure 2. Sun River Basin inflow/outflow comparison.**

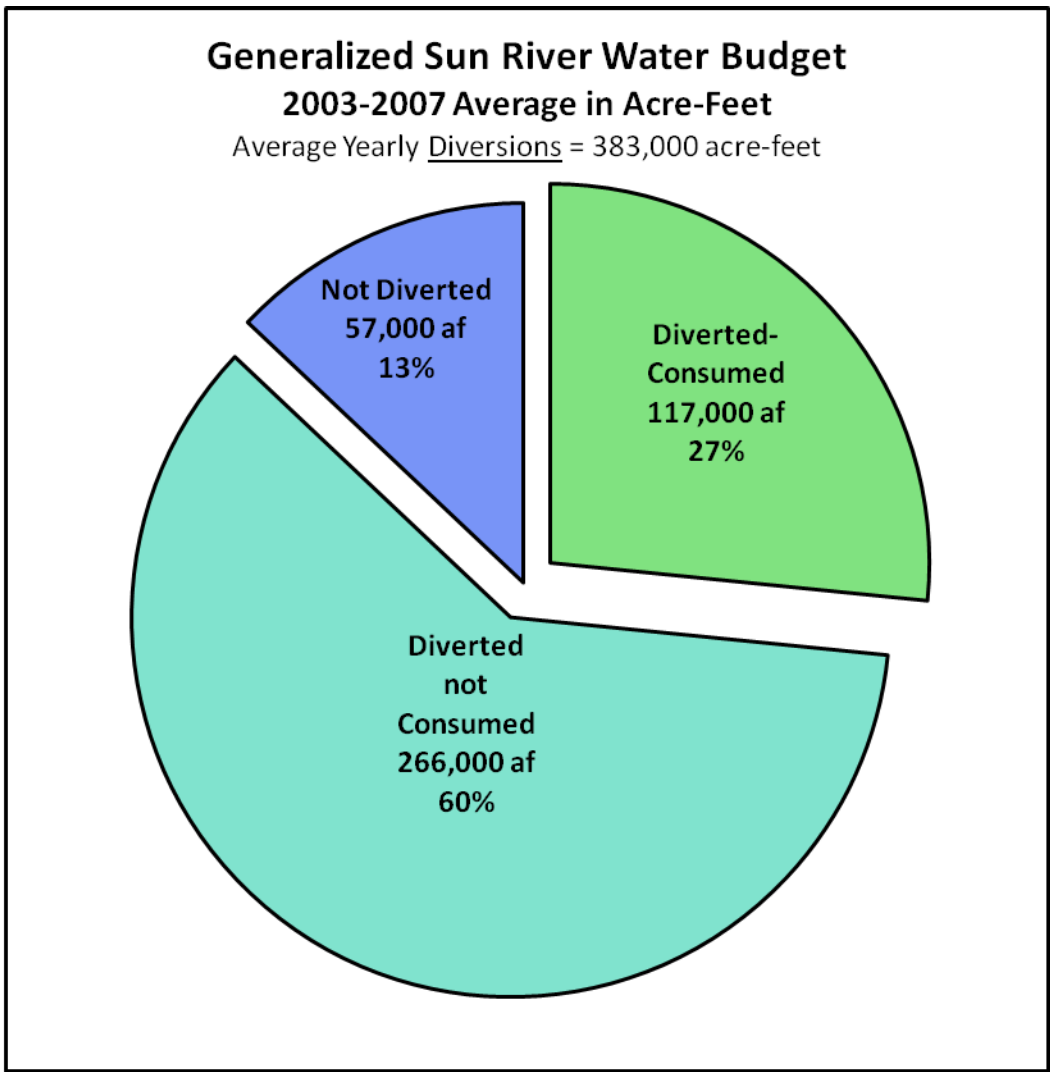



During most of the spring and summer, there is more water flowing into the basin from the higher elevations than leaves the basin at the mouth of the Sun River. This is because during the spring water is being stored in Gibson Reservoir, and because water is being used for irrigation by GID, Broken O Ranch, FSID, Elk Creek water users, Rocky Reef Ditch users, and Sun River Valley Ditch Company users. There are about 120,000 acres irrigated in the basin overall. During the fall and winter months, outflows from Gibson are reduced but the flow of the Sun River progressively increases downstream. This increase is due primarily to irrigation return flows, coming back through the groundwater, which are delayed by the time it takes the water to flow through the aquifer systems.

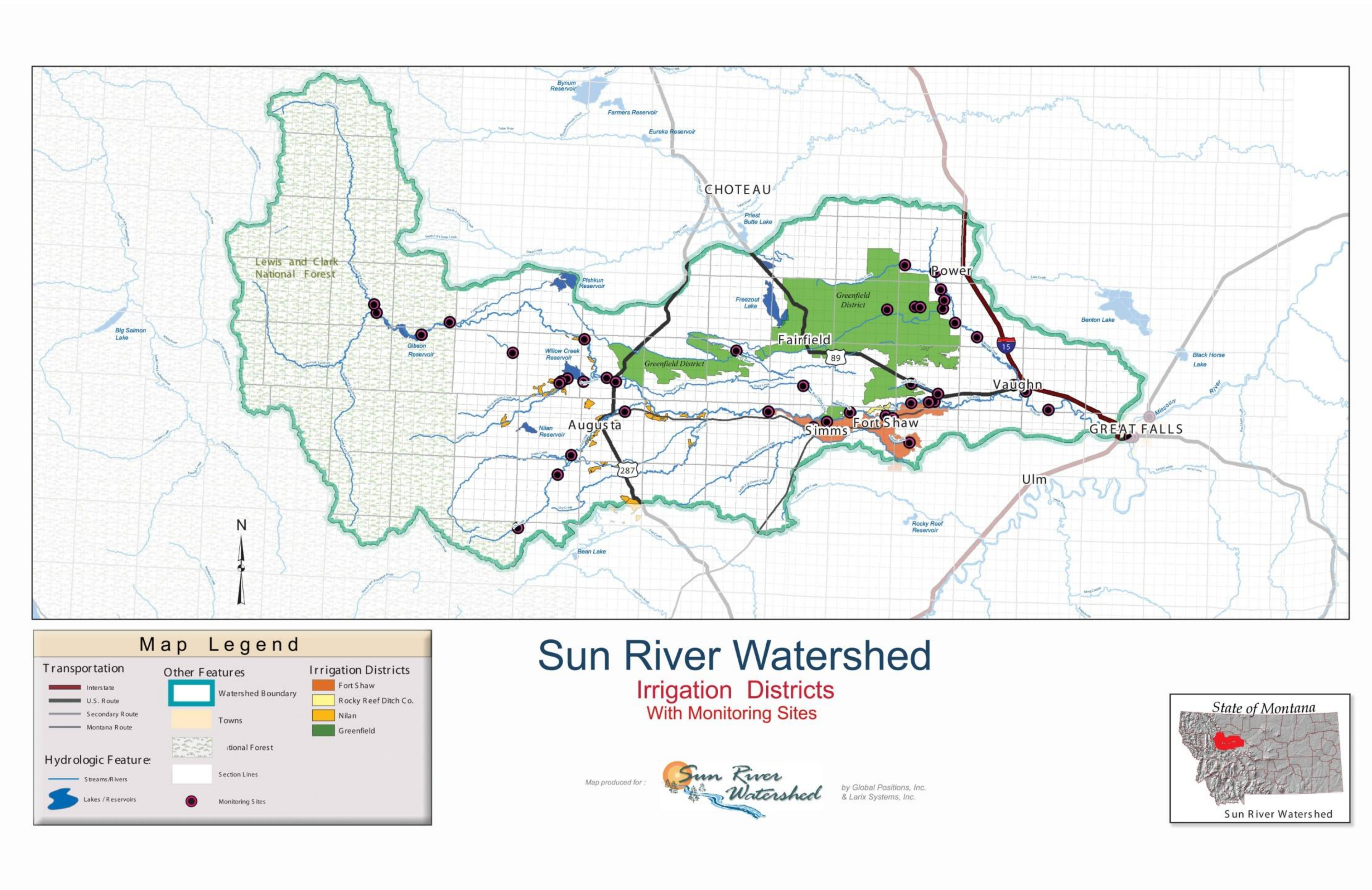
Sun River Basin inflow volumes for the 2003-2007 period averaged about 440,000 acre-feet per year, while outflows averaged about 320,000 acre-feet per year. Figure 3 is an approximation of an annual volumetric water budget for the watershed and depicts where the water in the basin goes. All but about 13 percent of the water in the Sun River was diverted at least once for the purpose of irrigation. Most of the 57,000 acre-feet that wasn't diverted was flow during the fall and winter, and spring runoff that could not be captured or stored. Of the water diverted for irrigation, approximately 27 percent or about 117,000 acre-feet was consumed. This works out to almost one acre-foot of water consumed per acre of irrigated ground, assuming 120,000 acres irrigated. The rest of the flow (60 percent or 266,000 acre-feet) was water that was diverted and not consumed, and that left the basin as return flow.

It is estimated that it would take about 450,000 acre-feet of controllable flow to meet all of the irrigation needs in the basin during a typical growing season. This would assume an overall irrigation efficiency of about 40 percent. Having this volume available would allow irrigators to get sufficient water to their crops, with the plants consuming about the 1.5 acre-feet per acre irrigated (about 175,000 acre-feet total). This would provide near optimal crop production. Unfortunately, this volume of water is not available during many years.

**Figure 3. Generalized Sun River water budget: 2003-2007.**



**Map 1. Sun River Watershed map including locations of irrigation districts and flow monitoring sites.**



## *Fisheries and Instream Flow Needs*

Montana Fish, Wildlife and Parks (FWP) manages the Sun River fisheries. FWP estimates that the main stem of the Sun River supports about 10,000 angler days per year. The primary game fish in the Sun River are rainbow and brown trout. Low-flow conditions in the river limit the trout populations to about 40-120 fish over 8 inches per mile. However, fish that do survive reach large sizes with over half of the fish being 15 inches or larger. A goal of the Sun River Watershed Group is to increase fish populations to 400 fish per mile. Doing so would require improving flow conditions in the river.

Table 2 contains FWP's recommended minimum and absolute minimum flows for the Sun River main stem. The recommended minimums are guidelines; there is no water right to protect these flows. Flows at these rates or higher would maintain food production at or near optimum levels for the aquatic community and provide bank cover, and spawning and rearing habitat. FWP does have a water right (a water reservation) for the absolute minimum flow recommended, which identifies the flow below which there is a rapidly declining level of aquatic habitat potential that provides for only a low fish population. However, these rights have a 1985 priority date and are junior to almost all irrigation water rights in the watershed.

**Table 2. Recommended minimum and absolute minimum Sun River flows by river reach.**

| | Recommended Minimum CFS | Absolute Minimum CFS (Water Reservation) |
|---|---|---|
| Diversion Dam to Mouth of Elk Creek | 220 | 100 |
| Elk Creek to Mouth | 220 | 130 |

In many years it has been difficult to consistently maintain the recommended minimum or even the absolute minimum flow in all reaches in the river year round. One persistent difficulty is during the winter period when GID is storing water in Gibson Reservoir for the upcoming irrigation season. Because inflow to the reservoir typically is at its lowest during this time of the year, comparatively little water is available to store or release to begin with. The operators are going into the winter with little knowledge of what snowpack will accumulate during the winter and what the spring precipitation will be. Reliable information on mountain snowpack will not be available until the late winter or early spring. Because the winter inflow to Gibson Reservoir can be predicted based on the fall reservoir inflow (Reclamation 2007), reservoir releases can be set during the fall and winter to achieve a desired storage level prior to the beginning of spring runoff. If the reservoir ended the previous irrigation season at a very low level and the projected inflow is low, then operators typically store much of the winter inflow to reduce the risk of not filling the reservoir to full pool by the end of spring runoff.

Typically, an effort is made to maintain a minimum winter release from Gibson Reservoir of at least 100 cfs. After the February 1$^{st}$ water supply forecast, winter releases can be adjusted, if necessary, based on the forecast and the reservoir level at the time. However, if winter conditions are severe, the potential for ice scouring of the banks may prevent the dam operators from increasing flows. During years when reservoir storages and winter inflow is low, winter releases have been cut back to around 75 cfs. In extreme cases, the outflow has been reduced to the absolute winter minimum of 50 cfs. Because there typically is not a lot of irrigation return flow or tributary flow added to the river between the Sun River Diversion Dam and the mouth of Elk Creek, low winter releases result in less than desirable winter flows that limit fish populations in the river.

During the irrigation season, the flow that goes over the Sun River Diversion Dam for senior irrigation water rights generally keeps the river flow above recommended minimums downstream to the FSID Diversion Dam. Below the FSID Diversion Dam, low water levels and high water temperatures often are a problem during the irrigation season. River managers attempt to maintain a minimum flow of 50 CFS at the Sun River at Simms gaging station, although flow has dropped below this level during recent years. Progressing downstream, the river flows steadily increase due to irrigation returns from GID, FSID, Broken O Ranch, and other irrigators.

# Water Appropriations

## *Reclamation's Sun River Project*

The Sun River Project (Project) facilities, authorized under the Reclamation Act of 1902, provide the capability to store, manage and utilize federal water rights in the Sun River drainage. The major Project facilities, constructed, owned by Reclamation, and operated by GID, are managed to deliver Project water by contract to users. Two irrigation districts are served by the Project, GID and FSID. GID contains approximately 87,000 irrigated acres, and FSID contains approximately 10,000 irrigated acres. The Project is the largest water user in the basin.

GID works with contract holders to set annual water allotments based on the latest water supply forecast. Because of the high demands compared to the water available in the basin and the priority of the Project, it often uses the bulk of flow of the Sun River.

## *Other Irrigation Water Rights*

Major consumptive private Sun River water users include the Broken O Ranch, Rocky Reef Canal Co, and Sun River Valley Ditch Co. The Nilan Water Users Association operates Nilan Reservoir, a State of Montana water project, and irrigates approximately 10,000 acres, mostly in the Elk Creek tributary drainage. There also are numerous private water rights for irrigating relatively smaller parcels of land, and for stock and domestic use. With the exception of the Broken O Ranch, most of these rights are junior to those associated with the Sun River Project.

## *Water Reservations/Reserved Water Rights*

Water reservations have been granted in the Sun River basin for current and future beneficial uses, including maintenance of minimum streamflow for fishery purposes. Water reservations were only granted to political subdivisions, the State of Montana or its agencies, or to the United States or any of its agencies. Water reservations maintain a 1985 priority date even though the water may not be put to beneficial use for decades. These rights are junior when compared to the larger irrigation water rights in the basin, and there is often insufficient flow left for them. Table 3 lists water reservations in the Sun River watershed.

**Table 3. Water Reservations in the Sun River Watershed.**

| Reservant | Purpose | Source | Rate CFS | Volume AF/yr | Acres |
|---|---|---|---|---|---|
| City of Great Falls | Parks irrigation | Sun River | 4.45 | 233.5 | |
| Montana DFWP | Instream flow | Elk Creek | 16 | | |
| | | Ford Creek | 12 | | |
| | | Willow Creek | 3 | | |
| | | NF Willow Creek | 3 | | |
| | | Sun River: Diversion Dam to Elk Creek | 100 | | |
| | | Sun River: Elk Creek to mouth | 130 | | |
| Cascade County CD | Irrigation | Sun River | 7 | 991 | 388 |
| Lewis and Clark County CD | Irrigation | Elk Creek | 1 | 151 | 60 |
| Teton County CD | Irrigation | Muddy Creek | 12 | 1785 | 804 |
| | Irrigation | Sun River | 3.7 | 542 | 252 |

## Water Storage

Water storage plays a major role in the Sun River Basin. Storage projects include Gibson, Pishkun, Nilan, and Willow Creek reservoirs. Water is stored during the winter and runoff periods, and then released to supply irrigation water to hundreds of users along the river and canal system. Water storage can also play a crucial role for recreation interests and fisheries in the basin, if releases coincide with times of need. Aside from direct recreation benefits at the reservoirs, releases for irrigation purposes can also indirectly increase stream flows when natural channels are used for conveyance or carry irrigation return flow.

Table 4 contains a summary of consumptive and non-consumptive water rights in the basin, which demonstrates the variety of uses and the volumetric extent of the various uses. More details on individual water rights can be found at the following DNRC web site: http://dnrc.mt.gov/wrd/water_rts/default.asp.

**Table 4 - Sun River Watershed water rights summary.**

| Purposes | Number of Rights | Volume (Acre-Feet) | Acres Irrigated | Percent of Total Rights | Percent of Total Volume | Comments |
|---|---|---|---|---|---|---|
| Agricultural Spraying | 2 | 1 | | 0.04 | 0.00 | |
| Commercial | 72 | 752 | 12 | 1.5 | 0.04 | |
| Domestic | 1338 | 5,550 | 1,091 | 28.7 | 0.28 | Includes wells |
| Fire Protection | 5 | 204 | | 0.11 | 0.01 | |
| Fish and Wildlife | 37 | 14,849 | | 0.79 | 0.76 | |
| Fishery (instream flows) | 11 | 201,458 | | 0.24 | 10.3 | |
| Industrial | 10 | 423 | 5 | 0.21 | 0.02 | |
| Institutional | 15 | 6 | 2 | 0.32 | 0.00 | |
| Irrigation | 756 | 1,457,362 | 521,882 | 16.2 | 74.7 | Some rights overlap |
| Lawn and Garden | 262 | 1,269 | 339 | 5.61 | 0.07 | |
| Mining | 1 | 1,814 | | 0.02 | 0.09 | |
| Multiple Domestic | 12 | 173 | 3 | 0.26 | 0.01 | |
| Municipal | 23 | 10,991 | | 0.49 | 0.56 | |
| Observation & Testing | 1 | 1 | | | 0.00 | |
| Other Purpose | 17 | 13 | | 0.36 | 0.00 | |
| Power Generation | 3 | 203,674 | | 0.06 | 10.44 | |
| Recreation | 15 | 270 | | 0.32 | 0.01 | Some rights overlap |
| Stock | 2072 | 53,028 | | 44.4 | 2.72 | |
| Wildlife | 14 | | | 0.30 | 0.00 | |
| Waterfowl and Wildlife | 3 | 98 | | 0.06 | 0.00 | |
| **Totals** | **4,669** | **1,951,936** | **523,334** | **100** | **100** | |

## Upper Missouri River Closure

In 1993 the Montana Legislature closed the Upper Missouri River drainage, including all tributaries, to most new appropriations of water (85-2-343, MCA). The Sun River and all water flowing into it is one of the affected tributaries. The closure was enacted due to water availability problems, over-appropriation, and a concern for protecting existing water rights, including downstream hydropower rights. Certain exemptions allow new water rights (permits) to be issued for limited non-consumptive, water storage of high spring flows, and other minimal consumptive purposes that do not adversely affect existing water rights. The closure also has an exemption for new permits that use water from the Muddy Creek drainage, if the proposed use will help control Muddy Creek erosion. With the exception of the Muddy Creek drainage, the closure makes new permits for additional consumptive uses from the Sun River basin unlikely, other than to implement water reservations. Projects that are pursued as a result of this Special Study will need to be evaluated, during project planning, to determine if water rights changes or new water rights are needed, and if any of the projects might be subject to the Upper Missouri River Closure.

## Previous Investigations Leading to the Special Study

The Water Management subgroup of the Sun River Watershed Group was formed in 2003. The goals of the subgroup are to: 1) improve flows in the Sun River for fisheries, and 2) while accomplishing this goal, maintain and/or improve irrigation production. The members of the subgroup represent a range of stakeholders, including GID and FSID, Reclamation, DNRC, the Broken O Ranch, Montana Fish, Wildlife and Parks, Trout Unlimited (TU), NRCS, and other private irrigators and interested citizens.

In working towards its goals, the subgroup operates, maintains, and helps fund the flow monitoring network in the watershed. This includes river and tributary stream gages, measurement of flows in irrigation canals and ditches, and the measurement of irrigation return flow. With this information, the group has developed a much better understanding of the hydrology of the Sun River system. Annual water budgets for the basin have been developed and presented to the group. Collecting, compiling, and understanding all this information is necessary for estimating what benefits various water conservation measures might provide, especially in regards to improving the flow in the Sun River.

A water management analysis was conducted by a consultant to the group during 2004 (Snowcap Hydrology 2004). This included a review and analysis of existing flow data, irrigation water management practices, and Reclamation project evaluations. Recommendations included improving irrigation efficiencies and reducing canal spillage, improving the ratio of delivered water to diverted water, using climate data to better anticipate crop needs, better use of water supply forecast information, reassessing recommended minimum outflows from Gibson Reservoir, better coordination of the release of stored water, and better education on efficient irrigation practices.

To better understand water diversions and returns to the system as a whole, the group conducted synoptic flow measurements during the 2004 (a lower quartile flow year) and 2005 (a year in the median range). Over two-day periods, when flow and diversion conditions were relatively stable, the flow of Sun River, its tributaries, and diversion were measured at various locations (up to 31 locations) throughout the watershed. The goal was to obtain snapshots of flow patterns in the watershed at the time of the synoptic measurements. The measurements were helpful in identifying where the river was gaining and losing water, and whether these gains and losses were predictable. Five synoptic measurement snapshots were made, including snapshots prior to the irrigation season, during the mid irrigation season, and near the end of the season (DNRC 2006).

In follow-up to recommendations in the Snowcap Hydrology Water analysis report, during 2006 and 2007 Reclamation used its River Operations Model, SUNAOP to investigate Gibson Reservoir winter operations and to evaluate whether instream flows could be increased in the Sun River below the Sun River and Fort Shaw Diversion Dams during the irrigation season (Reclamation 2007). The study found that it would be difficult to modify operations to increase instream flow during the irrigation season below the Sun River and Fort Shaw diversion dams without increasing irrigation shortages during drier years. In considering non-irrigation season operations, a water balancing method was developed through the study that could provide noticeable improvements in winter fishery flows during average and above average years, while protecting the irrigation water supply in low runoff years. Working from the Snowcap Hydrology report, Reclamation subsequently established a water-balance method to set minimum winter outflow rates from Gibson Reservoir. (Reclamation

2007b).

Although the Reclamation studies identified these operational measures for improving winter flows during many years, the studies also found that it would be difficult to increase Sun River instream flows to desired levels during the driest years. To start identifying other potential ways of improving Sun River flows, a "brainstorming" session was held by the Water Management Subgroup during September, 2006. The intent of this session was to generate ideas on ways to improve Sun River instream flow, while maintaining current levels of agricultural productivity. The session identified a number of potential structural and nonstructural measures, and discussions moved on to how some of these measures might be implemented.

In follow-up to this meeting, tasks were assigned and preliminary investigations into some ideas were begun. Investigations into seepage from the Sun River Slope Canal were conducted in 2007, with considerable seepage losses identified (TD&H, Inc. 2008). Near that same time, Reclamation and GID initiated an appraisal study of enlarging the storage capacity of Pishkun Reservoir, to investigate the potential to store and deliver more water, with some of the savings possibly designated for improved river flow. The FSID also began investigating ways of improving the efficiency of its water delivery systems, including the K-ditch (TD&H, Inc. 2010).

Studies were also conducted by the SRWG to identify the major sources of waste-water and irrigation return flows to the major tributaries on the lower portions of the Sun River. A gaging network was established on tributaries to Muddy Creek by Montana State University Extension Water Quality to identify primary sources of flow and sediment to that stream, (MSU 2006, 2007, and 2008). Similar investigations were conducted on Big Coulee by MSU (MSU 2007b and 2008b). These studies identified which drainages were producing the most water and sediment, and are helpful in focusing water-conservation efforts. DNRC has been gaging Mill Coulee flows since 2001in order to understand the patterns of return flow and unused water from that stream that returns to the Sun River. The Sun River Watershed Group has been monitoring tributary return flows from FSID for similar purposes.

In order to tie all this information together and develop a plan for future actions, the Watershed Group looked at incorporating all the ongoing efforts and future potential projects into a coordinated Special Study during the later part of 2008. The study was funded by Reclamation, with a 50-50 non-federal cost share. The Special Study was to be an inventory and analysis of proposed measures that could be implemented to improve streamflow in the Sun River while maintaining the irrigated agriculture economy of the area. Although the purpose of the Special Study was not to fund project implementation, it does include looking at steps that can be taken towards project implementation. A critical part of the study is the development of a procedure by which project water savings can be allocated between improved streamflow in the Sun River and irrigation needs.

# PROJECT IDENTIFICATION AND EVALUATION

The first task of the Special Study was identifying all potential options that might result in saved water and shared benefits to agriculture and instream flow. This included those projects identified in previous studies, and those brought forth in the initial brain-storming session.

With the options identified, a procedure to initially screen the projects was developed. The intent was to remove projects from the analysis that had a low potential to provide shared benefits or feasibility before devoting resources to them. The initial screening asked the following questions:

- Does the project have the potential to provide additional water for irrigation and instream flow?
- Does the project have the potential to affect water users or instream flow?
- Are there any insurmountable hurdles to implementing the project?

The answer to the first two questions needed to be affirmative and the answer to the last question needed to be no. After considering these criteria, a number of the projects were dropped from further consideration. Some more general basin-wide water management efforts, such as installing and maintaining measuring devices, were not evaluated in the Special Study because these efforts are ongoing and it would be difficult to quantify actual amounts of water saved through these measures.

Following the initial screening, potential projects that remained on the list were categorized by project type and evaluated to assess potential costs, benefits, and other opportunities and constraints. For many of the projects identified, there was little if any available information to assess them appropriately. A consultant was hired to assist with the Special Study and help with a preliminary engineering assessment of potential projects. The intent of these assessments was to develop a preliminary project concept, including an estimate of project dollar costs and annualized costs, and to estimate the benefits that the project could provide in terms of saved water. Enough information needed to be compiled to describe each project's potential and to compare projects. Other potential benefits, such as water quality, also were assessed, but in a more subjective way. The potential projects were placed into the following four categories:

1. Those that improve water delivery system efficiencies
2. Reservoirs, which would include new reservoirs or improvements to existing reservoirs
3. On-farm efficiency improvements
4. Other water management measures

Once the projects were identified and the necessary information compiled, a spreadsheet was developed to make ranking and comparing the projects easier. The spreadsheet included the initial screening criteria and other criteria to assess costs, and potential water savings. The spreadsheet can be found in Appendix A.

Developing a methodology for allocating saved water was an important part of the Special Study. An overall purpose of the Special Study is to identify and set out procedures for implementing projects that result in the joint benefits of improved agricultural productivity and enhanced streamflow in the Sun River. The methodology developed and described later in the report strives to achieve benefits that are equitably shared.

The following was the initial list of potential projects, by category.

# Potential Projects by Category

**Category 1 – Delivery Systems:**

1. **Canal lining**
2. **Control structure on the larger irrigation district canals**
3. **Automation of water delivery systems including field headgates**
4. **Pump-back systems to reuse waste-water that would otherwise flow to Muddy Creek and other tributaries**
5. **Replace some ditches with pipelines to deliver water to farm headgates or new sprinkler systems**

**Category 2 – Reservoirs:**

1. **Increase the height of Gibson Dam to increase the storage of Gibson Reservoir**
2. **Increase the ability to fill and release water from Willow Creek and Pishkun Reservoirs and increase efficiencies through timing of the fill**
3. **Build new off-stream water storage reservoirs.**
4. **Build new or expand re-regulating reservoirs within irrigation districts**
5. **Increase the height of the Pishkun Dikes to increase the storage of Pishkun Reservoir.**
6. **Review the water levels that are maintained to protect reservoir-outlet fish screens at Pishkun Reservoir; see if there may be alternative ways to protect the fish screens.**

**Category 3 – On-Farm:**

1. **Improve on-farm irrigation/pivot efficiency through training and improved equipment.**
2. **Convert flood irrigation systems to sprinkler irrigation**
3. **See if improvements can be made in how farmers order water from their irrigation district; models for anticipating orders and actual ordering process.**

**Category 4 – Other Water Management Measures:**

1. **Water banking concept: allow water users to store water in Gibson for later instream flow release, especially during drought years.**
2. **Buy out senior water rights that would like to change their water rights or lease their rights to instream uses.**
3. **Look at ways to manage risk, i.e. insurance for water users to mitigate increased risk of not filling Gibson Reservoir due to higher winter release rates:**

# Project Screening and Potential Projects to Investigate Further

## *Projects that were not investigated further in this Special Study*

The following potential projects were identified in the initial stages of the Special Study but were not pursued further because they did not pass the initial screening criteria. Each project is described below, with a short discussion of the reasons why the project was not pursued further.

### Increase the height of Gibson Dam to increase the storage of Gibson Reservoir:

Gibson Reservoir fills and spills during most years. A larger reservoir might be able to capture and store more water for the upcoming irrigation season, or carry-over stored water from a dry year that follows a wetter year. When there are back-to-back drought years though, a larger Gibson Reservoir probably would not capture and supply more water because the reservoir might not even fill to the existing 96,477 acre-feet capacity during either year.

Gibson is a concrete-arch dam with a drop-inlet spillway. Modification to these structures to allow for a higher pool level would be very expensive. Additionally, there may be topographic limitations to increasing the full-pool elevation, and concerns about backing more water into the surrounding National Forest including the Bob Marshall Wilderness Area. Using a computer simulation model of the Sun River system to determine “firm” reservoir yield for various sizes and to model what an optimal reservoir size might be could provide more information to determine if this option should be explored in more detail in the future. Although the enlargement of Gibson might have some merit in the future, the length of time and high costs just for project evaluation precluded pursuing this option through the Special Study.

### Build new off-stream water storage reservoirs:

The intent here was to investigate sites on the middle portion of the Sun River where surplus high flows from tributaries could be captured and diverted to new off-stream reservoirs and later released into the Sun River. Group members asked that the potential of two sites be investigated: one on Simms Creek, and the other in Cutting Shed Coulee. After preliminary investigation, it was determined that neither of these sites could store enough water to improve instream flows in the Sun River, and that construction costs would be prohibitive. With that determination, the group removed these potential projects from further investigation at this time.

### Review the water levels that are maintained to protect fish screens at Pishkun Reservoir; see if there may be alternative ways to protect the fish screens:

There are screens at the outlet of Pishkun Reservoir to keep fish from entering the Sun River Slope Canal. During the winter, the water level above these screens needs to be high enough to prevent ice damage. It was initially thought that this was resulting in an additional volume of storage that had to be carried to the fall and was inaccessible for delivery to GID during the irrigation season. Although water levels may be important to protect the fish screens, GID can place protective berms around the screens or lower the water level enough so ice does not reach the screens. After discussions with GID, the project was not considered further because protection of the fish screens was not having an effect on reservoir storage or water deliveries.

### Look at ways to manage risk, i.e. insurance for water users to mitigate increased risk of not filling Gibson Reservoir due to higher winter release rates:

Following dry years, when Gibson Reservoir storage is depleted and streamflow into the reservoir is low, winter releases from Gibson Reservoir are reduced to below 100 CFS. Most of the time, the upcoming winter and spring will produce enough snow and rain to fill the reservoir the following year. Although the low winter release will have turned out to have been unnecessary during most years, it is implemented because, for GID irrigators, it insures that Gibson Reservoir fills in all years. Simply put, if a very dry winter and spring were to follow the previous dry year that depleted reservoir storage, Gibson Reservoir would not fill. The idea behind this option would be to allow instream interest to a guaranteed 100 cfs winter reservoir release, if they were willing to take out insurance on the reservoir filling. In years when the reservoir did not fill because of the increased winter release, GID irrigators would be compensated for the agricultural water value lost due to the higher winter release. The alternative was not pursued further due to the lack of an established procedure, lack of interest, and because both instream flow interests and GID Board did not consider it workable at this time. GID Board discussed this option and was of the opinion that it would be too difficult to manage crop-loss claims from irrigators during the years when the reservoir did not fill.

**Water banking concept: allow water users to store water in Gibson for later instream flow release, especially during drought years**:

Water banks broker voluntary transactions between people trying to sell or lease water rights and those trying to purchase rights or leases. A bank also can become a depository of water rights that are available for lease or transfer, and helps to set prices for purchase and sale. Montana does not have a water banking system, but agricultural water rights can be leased for instream uses between private parties. Although water banking is not prohibited, this option was dropped because there currently is not a water banking system in Montana. Purchasing or leasing water rights by other means is discussed under Category 4: Other Water Management Measures.

**See if improvements can be made in how farmers order water from their irrigation district; models for anticipating orders and actual ordering process:**

Within the irrigation districts, individual water users can order water with 48-hours advance notice or cancel water deliveries from the district with 24-hours advance notice. Often, the orders or cancellations come too late for the operators to balance flows in the ditch systems, which results in waste-water spills to coulees that feed drainages such as Big Coulee, Mill Coulee, and Muddy Creek result. With longer lead time for water orders and order cancellations, ditch riders might be able to reduce these operational spills. Implementing such a procedure may require incentives to encourage individual farmers to participate. Although changing the ordering system may have some merit in the future, the GID board felt the current system is working and that modifying the system would not result in substantial water savings at this time.

## *Projects that Passed to Initial Screening Phase and were Analyzed Further in the Special Study*

The following section describes projects that passed the initial screening and were analyzed further in the Special Study. Each project and its potential costs and benefits are described. The projects are ordered by category. All cost figures are preliminary.

### Category 1: Delivery System Improvements

Delivery systems include the main canals which divert water from the source to the irrigated lands, and the lateral ditches, pipelines and field ditches which distribute the water within the irrigated land base. Water is lost from canals and ditches as seepage and evaporation. Because evaporation losses are generally minor, they were not considered further. Reducing the amount of water lost at the end of canals, ditches and pipelines as operational spills presents another opportunity to conserve water through delivery system improvements. Operational spills occur when there is excess water within the system that can’t be used, such as immediately following a rainstorm. In other cases, operational spills occur because there is a certain amount of carriage water required to get water to the very end of a system, especially on large irrigation districts. The following are potential projects that fall in the Delivery System Improvements category.

***Line the Sun River Slope Canal near Augusta:*** The Sun River Slope Canal conveys water from Pishkun Reservoir to GID irrigated lands. The canal is 39 miles long with a capacity of 1,600 cfs. It was built between 1917 and 1919 and is thought to lose substantial amounts of water to seepage. A study by the Sun River Watershed Group investigated seepage in an 8.8 mile length of the canal from the Highway 287 Bridge near Augusta to the beginning of the Spring Valley Canal. Preliminary water loss estimates from the 2007 study estimate that 10,000 to 12,000 acre-feet is lost annually to seepage in this section of canal (TD&H, Inc. 2008). This option would line a 3-mile length of the canal which was determined to have particularly high seepage rates. A synthetic liner would be used. The overall cost of the project might be $3,000,000.

***Use J-Lake Storage to reduce waste-water flows to Muddy Creek:*** J-Lake is a re-regulating storage reservoir on the headwater of Spring Coulee near the East Bench area of GID. Flows to Muddy Creek from Spring Coulee are estimated to be up to 20,000 acre-feet per (MSU 2006, 2007, and 2008) year, much of which is return flow and waste-water losses. An existing J-Lake dam and reservoir captures some flow and wastewater from Canal laterals and drains, and passes this water either into a GID lateral canal, where it can be used for irrigation, or into Spring Coulee, where it cannot be used and flows as waste-water into Muddy Creek. Currently, J-Lake only has about 20 acre-feet of storage capacity and it is difficult to manage the flow of waste-water into Spring Coulee with this small volume of storage and with the existing configuration of the J-Lake dam structure. This option would increase the height of the J-Lake dam and dikes, and modify the dam control structures so that storage in the lake could more effectively be used to reduce waste-water flow. Through more efficient use of delivered water, GID could save water both above and below J-Lake. Depending on the amount of storage provided, the project has the potential to save from 500 to 8,000 acre-feet of water annually at an estimated cost of up to $500,000 (Morrison-Maierle, Inc. 2011).

***Construct re-regulating storage on Tank Coulee to reduce waste-water flows to Muddy Creek.*** Tank Coulee is another tributary to Muddy Creek on the East-Bench portion of GID. MSU (2006) has estimated that about 10,000 acre-feet of waste-water and irrigation return flow is lost down Tank Coulee during the irrigation season. This project would construct a new re-regulating reservoir on Tank Coulee to recapture flow off GID and minimize the return flow to Muddy Creek. This project would be operated in a similar manner to that described for J-Lake. It might be possible to save up to about 5,000 acre-feet of water annually with this project. The estimated cost might be $1,650,000 to $3,200,000 (Morrison-Maierle, Inc. 2011b).

***Investigate Using in-canal storage on the GID Sun River Slope and Spring Valley canals:*** This option would use check structures and in-canal storage on the Sun River Slope and Spring Valley canals on the GID system to reduce operational spills from these canals. The project, as analyzed, was to upgrade two existing check structures, and to install two new ones. Because of the limited capacity to store water within the canal prisms, the total project only has the potential to supply benefits of about 250 acre-feet per year. Estimated construction costs are $1,600,000 (Morrison-Maierle, Inc. 2010).

***Investigate the use of pump-back systems to reduce the flow of water from GID into Muddy Creek and other tributaries:*** There are a couple of existing systems on the eastern portion of GID that pump wastewater and return flow from drains and coulees back up into lateral ditches that are part of the GID water delivery system. These pumps capture and reuse water that otherwise would be lost from the system. Unfortunately, these pump-back systems are used infrequently because of the high power costs to operate them. This option would upgrade existing systems to more efficient variable-speed pumps, and also might include the installation of new pump-back systems. The option would possibly include the sharing of pump-back system operational costs, along with a sharing of benefits. Preliminary analyses indicate that pump-back systems might save about 1,000 acre-feet of water annually, per site. The project cost might be $50,000 to $100,000 per site (Morrison-Maierle, Inc. 2011b).

***Install pressurized pipe to deliver water from the GID South Canal to the Simms area:*** An analysis of data collected by MSU (2007b and 2008b) and DNRC indicate that total water losses from return flow and waste-water to Big Coulee might average about 10,000 acre-feet of water per year. One way to reduce some of these losses would be to increase the efficiency of water deliveries from the main GID system to the lower Simms Bench area of the District. Currently, water is diverted from the GID South Canal into Big Coulee, and then re-diverted from Big Coulee further downstream into the Beale Canal to irrigate a 1,565-acre unit of GID in the Simms area. Inefficiencies in these water transfers can result in operational spills. This project would install a pipeline to convey water directly from the GID South Canal to the lower Simms Bench area. Because of the elevation drop from the South Canal to the lower bench, the project would also provide the benefit of water under pressure, which could be used to run sprinkler irrigation systems. It is estimated that the project would cost $3,500,000 and might save about 1,600 acre-feet of water annually (Morrison-Maierle, Inc. 2010b).

***Install pressurized pipe to deliver water from the Mill Coulee Canal to the Ashuelot Bench:*** An analysis of flow data collected by DNRC indicate that from 6,000 to 9,000 acre-feet of return flow and wastewater flows back to the Sun River through Mill Coulee during the irrigation season. Most of this water originates from the Ashuelot Bench area of GID. This potential project would use pipe to deliver water under pressure from the Mill Coulee Canal to about 2,700 acres of irrigation on the Ashuelot Bench portion of GID. It would also include converting a substantial amount of flood irrigation to sprinkler systems. It is estimated that this project has the potential to save about 5,400 acre-feet annually and would cost about $7,500,000 (Morrison-Maierle, Inc. 2010b).

***Replace Lateral ditches on the East Bench of GID with low-pressure pipelines:*** The majority of the water delivered to farm turnouts on the East Bench of GID is through lateral ditches which are unlined, or lined to a varying degree of effectiveness. Laterals could be replaced with low-pressure pipe, which might reduce seepage losses and improve delivery efficiencies. Using pipe could reduce operational spills that result when the ditches are run relatively full to ensure that enough water is available to the users at the very end of the ditch system. The benefits of using low-pressure pipe would depend on the lateral, likely would be relatively small for individual systems, but could provide significant cumulative benefits if many laterals were upgraded. Costs might range from $100,000 to $200,000 per system, and save from 100 to 200 acre-feet annually, per system (Morrison-Maierle, Inc. 2011b). Cumulatively, there is the potential for these types of projects to add up to a significant volume of saved water.

***Rerouting and piping of the Fort Shaw Irrigation District C-K Canal:*** This project would re-route an inefficient and leaky portion of the FSID C-K Canal and replace a portion of the canal with PVC pipe. The project would save about 1,200 acre-feet of water annually. It would cost about $149,000 (TD&H, Inc. 2010). This will be accomplished by abandoning nearly 7,000 linear feet of a very leaky ditch, while maintaining service to existing irrigators using a series of pipeline drops from an upslope ditch.

***Convert portions of the FSID l-4 and D-13 lateral systems to pipelines:*** This project would replace 4,860 feet of FSID ditches that have high rates of seepage with PVC pipe. This will be accomplished by replacing 4,860 feet of very leaky, open ditches with PVC pipe. It is anticipated that this project will save about 4,200 acre-feet annually. The estimated cost is $222,000 (Fort Shaw Irrigation District 2011).

## Category 2: Reservoirs

There is a total of about 170,000 acre-feet of reservoir storage in the Sun River basin. For comparison, the average annual inflow to Gibson Reservoir is about 590,000 acre-feet. During most years, a substantial amount of the spring runoff water leaves the basin in a relatively short period of time because there is insufficient capacity and infrastructure to capture all of it. Reservoir projects could include the construction of new reservoirs, expansion of existing reservoirs, or changes in the operations or delivery of water to reservoirs. The following is a description of the reservoir projects that passed the Special Study initial screening.

***Improve the Ability to divert water to Willow Creek Reservoir:*** Water is diverted from the Sun River to the Willow Creek Feeder Canal, which then flows into Willow Creek. From there, Willow Creek flows into Willow Creek Reservoir, where the water is captured and stored for later release back to the Sun River to meet peak irrigation demands. Because of problems with erosion on Willow Creek upstream of the reservoir, diversions of Sun River water into the reservoir feeder canal are limited to a rate of about 75 cfs. This constrains how fast the reservoir can be filled and can reduce the total capture of water during the brief period that water might be available for storage. If more water could be diverted to and stored in Willow Creek Reservoir during times of higher runoff, diversions could be reduced when less water is available and other demands are higher. Additional modeling would be needed to quantify the potential water savings benefits of this project. The most recent estimated cost estimate for stabilizing the Willow Creek channel, to allow for diversion rates of up to 300 cfs to Willow Creek Reservoir, was $1,700,000 (Land and Water Consulting, Inc. 1998).

***Increase the storage capacity of Pishkun Reservoir:*** Pishkun Reservoir has an active storage capacity of about 30,686 acre-feet and is formed by eight earth-fill dikes with heights ranging from 10 to 50 feet and an overall length of 9,050 feet. There is no spillway for the reservoir and water is fed into the reservoir by the Pishkun supply canal. This option would increase the capacity of Pishkun Reservoir by raising the height of the dikes. Storage increases of 10,000, 16,000, and 26,000 acre-feet were examined (Reclamation 2010). Water rights associated with the expanded storage might be obtained by: 1) transferring rights associated with Gibson Reservoir that are now ineffective due to sedimentation to Pishkun Reservoir, and (2) a new water right for the storage of high spring flows that would be within the exceptions of the upper Missouri Basin closure (§85-2-343 MCA). The additional storage would provide a more reliable water supply for GID, which might in turn free up water that could be used to improve instream flow in the Sun River. The estimated cost is $29 million for a 26,000 acre-feet storage increase (TD&H, Inc. 2008b). Reclamation is still evaluating this alternative for safety of dams concerns and is scheduled to provide a report on the evaluation in 2012. However, this should be considered a screening-level evaluation only. Additional and extensive analysis and investigations would be necessary to advance this alternative further, if this initial evaluation were favorable. It should also be anticipated that extensive efforts will be required to evaluate potential environmental and cultural related concerns with enlarging the reservoir. An increased capacity at Pishkun Reservoir might have to be accompanied by an increase in the capacity of the supply canal, in order to take advantage of excess water to fill the reservoir which sometimes is only available during short windows of time.

***Improve the Ability to divert water to Pishkun Reservoir:*** Although the capacity of the supply canal to Pishkun Reservoir generally is adequate, there are times when it may be advantageous to move water to Pishkun more quickly. This option would investigate that possibility. The canal has an existing capacity of approximately 1,400 cfs, and this capacity would need to be increased for the 12.1 miles of canal above Pishkun Reservoir. This project would need to be modeled through computer simulations of the system before an optimal canal size could be determined and before potential water savings benefits could be estimated. Potential costs for increasing the capacity of the supply canal have not been estimated.

### Category 3: On-Farm Irrigation Efficiency Improvements

Possible on-farm efficiency improvements include conversion from flood to center-pivot sprinkler irrigation, better managing irrigation water by applying no more water than the crop needs, and converting on-farm open ditches to PVC pipe to reduce water loss. Although these types of projects could be undertaken by individual operators, larger, coordinated projects would be needed to accumulate measurable savings where a portion might be used to improve stream flows. The Ashuelot Bench and Simms area projects, described in the Delivery System Improvements section, include improved on-farm efficiency components. No other project blocks have been identified at this time.

### Category 4: Other Water Management Measures

***Investigate the costs and benefits of purchasing or leasing senior water rights and changing them to instream flow use:*** This option would investigate potential benefits and opportunities for purchasing existing irrigation water rights and changing the use to instream flow. Instead of being diverted for irrigation use, the water for these transferred rights would be left in the Sun River to provide instream-flow benefits. This type of transfer would need to be negotiated by willing sellers and buyers. The option most likely would involve leasing water rights for instream flow, rather than a permanent water rights change. The costs of water would need to be determined between buyer and seller and would vary based on market conditions. For Montana instream flow leases that TU was involved with, costs were $21 to $25 per acre-foot (Ziemer, 2011). Although the Sun River Watershed Group would not actively pursue such purchases and changes, it might be able to offer assistance to willing buyers and sellers to ensure that transfer goals are realized without impact to other water users.

## Evaluation of Screened Alternatives

The potential projects that passed the initial screening were incorporated into an evaluation spreadsheet. The spreadsheet included the initial screening criteria and other criteria to assess costs, and potential water savings. The spreadsheet can be found in Appendix A.

The first set of screening criteria in the spreadsheet, beyond the preliminary screening criteria, is an estimate of the amount of water that the alternative might save. These savings are tabulated as an annual volume in acre-feet. The next criteria addressed was where in the river system might some of the saved water provide instream-flow benefits. Projects also were examined as to whether or not they might provide benefits both to irrigation and instream flow purposes. Estimates of project costs also were developed. This included total costs to build or implement the project, annual cost, and cost per unit of water saved in acre-feet. For some projects, where costs were very uncertain due to limited information for analysis, a max-min cost range was used. Alternatives also were assessed for their potential complexity, from an administrative, legal and permitting standpoint. Additional studies that would be required before a project could be constructed or implemented were identified and listed too. And an estimate was made of the time it might take to implement the project. Agencies and groups that might be involved in development of the alternative were identified. Finally, a judgement was made on what the potential was to obtain funding for the project, from grants and other sources.

After considering all of this information, the final selected projects were compared and ranked. This ranking did not strictly order the projects from highest to lowest, but partitioned projects which were considered to have the most potential into three groups based on when it might realistically be possible to implement the projects. Group 1 projects were those that ranked high and which the group could pursue now or in the near future. The second group of potential projects consisted of those which the group considered to be good projects overall, but where there was a lot more work to be done before the projects could be implemented. The third group consisted of projects that might have some potential, but were complex, possibly expensive for the benefits that could be realized, and not workable at this time………but to still consider during future planning. A final fourth group contains projects that were dropped from further consideration at this point in the project screening.

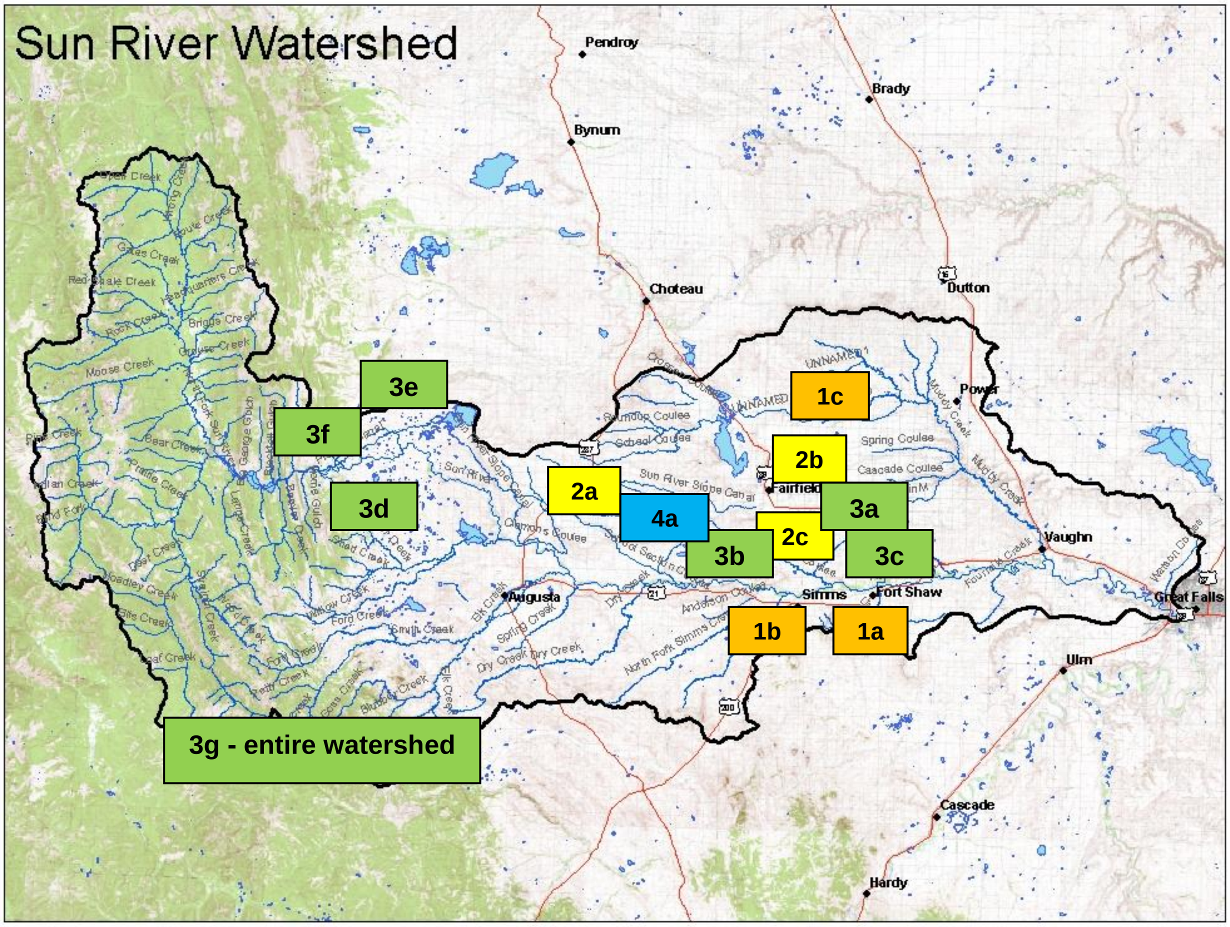
# Selected Projects by Group

Table 5 lists projects that the group believes have potential, and that it would like to pursue further. The exception is the Group 4 project, which was found to have a low potential to provide substantial water-savings benefits. The project groups are ordered by the amount of time it might actually take to implement the projects. Map 2 shows the location of the projects within the Sun River watershed. All of the costs listed in Table 5 are preliminary.

**Table 5. Selected Projects by Group.**

| **Group 1: Projects with good potential that the SRWG should work towards implementing in the short term** | | |
|---|---|---|
| *Project Description* | *Estimated Time to Implementation* | *Estimated Cost* |
| FSID C-K pipeline | Project construction completed | $149,000 |
| FSID L4 and D13 pipelines | Ongoing: 1 year to completion | $222,000 |
| GID pump-back systems | May involve multiple projects over a period of 1-to-5 years | $50,000 to $100,000 per system |
| **Group 2: Projects for the SRWG to work towards in the medium term where more detailed analysis is needed and which would require more substantial funding** | | |
| *Project Description* | *Estimated Time to Implementation* | *Estimated Cost* |
| Sunny Slope canal lining | 5-to-10 years | $3,000,000 |
| J-Lake re-regulating storage | 5-to-10 years | $500,000 |
| Ashuelot Bench pressurized pipe and improved efficiencies | 5-to-10 years | $7,5000,000 |
| **Group 3: Projects for SRWG to continue to investigate for long-term planning; these projects may be expensive or require substantial coordination and funding** | | |
| *Project Description* | *Estimated Time to Implementation* | *Estimated Cost* |
| Tank Coulee re-regulating storage | 10-to-20 years | $1,650,000 - $3,200,000 |
| Pressurized pipe to Simms area with improved efficiencies | 10-to-20 years | $3,500,000 |
| GID low pressure pipe delivery system projects | 10-to-20 years | $100,000 - $200,000 per system |
| Willow Creek Reservoir flow delivery rate increase | 10-to-20 years | $1,700,000 |
| Pishkun Reservoir Enlargement | 5-to-10 years | $29,000,000 |
| Pishkun Reservoir flow delivery increase | 10-to-20 years | Not available |
| Water rights changes to instream flow purposes | 10-to-20 years | $20 per acre-foot or more |
| **Group 4: Project that are currently considered to have a low potential for providing benefits** | | |
| *Project Description* | *Estimated Time to Implementation* | *Estimated Cost* |
| In-canal check structures | None | $1,600,000 |

## Map 2. Special Study Potential Projects Location Map.




| Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|
| 1a. FSID<br>C-K Pipeline | 2a. GID<br>Canal Lining | 3a. GID<br>Tank Coulee | 4a. GID<br>In-Canal Checks |
| 1b. FSID<br>L4 & D13 Pipelines | 2b. GID<br>J-Lake | 3b. GID<br>Simms Area | |
| 1c. GID<br>Pump-back Systems | 2c. GID<br>Ashuelot Bench | 3c. GID<br>Low Pressure Pipe | |
| | | 3d. GID<br>Willow Creek | |
| | | 3e. GID<br>Pishkun Enlargement | |
| | | 3f. GID<br>Pishkun Delivery | |
| | | 3g. Watershed<br>Water Rights | |

# IMPLEMENTATION PLAN

This section outlines a plan for further evaluating and implementing the projects that have potential to save water and provide shared benefits to agriculture and instream flow. Basic procedures that might be followed, from feasibility studies through project construction, are discussed. Because every project is different, this implementation plan is general rather than project specific. An important component of any project selected would be to develop a plan for sharing the saved water between irrigation and instream uses. Following the general implementation plan discussions is a specific example of an ongoing project that is being implemented under the Special Study framework.

## Project Evaluation

Many of the projects discussed in this report have been evaluated at the conceptual level because only enough information has been assembled on the project to determine if it might be workable, and to develop a rough estimate of project costs and water-saving potential. Costs estimates in this report might be, at best, within about 25 percent of actual 2012 costs.

Projects that the Watershed Group intends to proceed with would need to be brought from the conceptual design level to the feasibility level. This would include a more detailed engineering evaluation of project components, and a more detailed estimate of project capital costs, as well as operation and maintenance costs. A more thorough evaluation of the water-savings potential of the project also would be required. This might include on-site evaluations during the irrigation season to determine flow conditions at the project site and to evaluate water-savings potential under a variety of conditions. The details collected during this stage of the project evaluation could be used to make a final decision on whether it would be worth pursuing the project.

Projects that the group chooses to proceed with, and which there is funding for, would continue to final design and through all appropriate environmental compliance and permitting activities. This would be the level of design required before construction could proceed. The final design will contain a much more refined estimate of project costs.

## Developing a Methodology for Allocating Saved Water

The overall purpose of the Special Study is to identify water conservation projects that have the potential to improve agricultural productivity and enhance streamflow in the Sun River. In the past, a number of water conservation projects have been implemented in the watershed. Many of these projects have been successful in improving crop production and in decreasing return-flow water to lower Sun River tributaries, such as Muddy Creek, Mill Coulee (photo 3), and Big Coulee, but they haven’t necessarily resulted in improvements in flow to the reaches of the Sun River where flow is most critically needed. The reason for this is that, during most years, there are irrigation water shortages and the water that is conserved is simply re-distributed and used by irrigators to decrease crop-water shortages.

**Photo 3. Return and waste-water flow in Mill Coulee.**


Part of the plan for the Special Study was to develop methodologies for sharing the benefits of saved water between instream and agricultural uses. An underlying principle to this sharing of benefits is the sharing in the responsibility to procure funds to implement the projects that result in water savings. Although the specifics of how benefits are to be shared would vary from project to project, a general agreement among participants is that water savings will be shared equitably between irrigation and instream uses. Agreements also likely will have adaptive management stipulations for sharing the pain when unusual conditions occur, for instance, during extremely dry years. Water-sharing agreements could be entered into between irrigation districts and other irrigation water rights holders, and entities that represent instream flow interests, such as FWP and TU.

Binding agreements as well as cooperative relationships would need to be established between project partners to ensure that the benefits of water conservation projects are shared as intended. Agreements might need to specify how the project is to be paid for and by whom, who will be responsible for operating and maintaining the projects and associated costs, how water savings will be tallied, and how the water savings allocated to instream flow will be realized in the river, and when and where. Because there is not a lot of precedent in Montana for these types of agreements, parties will need to be creative and flexible. After an initial agreement is made for one project identified in the Special Study, it could be useful as a template on which subsequent projects can build. A potential outline of what this type of agreement might look like is attached in Appendix D.

## Operation and Maintenance of Projects

Most projects, once they are constructed, will need to be operated and require periodic maintenance. There also will be annual costs for operating some projects, such as the power costs to operate pump-back systems. During project planning these costs will need to be recognized and factored into funding. Water-sharing agreements might contain stipulations as to which parties are responsible for operation and maintenance costs.

## Obtaining Project Funding

It is likely that the costs of most projects will be beyond the capacity of what any single user will be able to pay for. Because the projects will provide shared benefits, the Sun River Watershed Group will work with the project beneficiaries to obtain project funding. Funding might come from a combination of government and private sources. For feasibility level studies, project planning grants might be obtained through the DNRC Renewable Resource Project Planning Grants program. DNRC Renewable Resource Grants and Renewable Resource Loans might be a source for funds for implementation of small to mid-sized projects. Other potential grant sources include Reclamation's WaterSMART, FWP Future Fisheries, and NRCS programs such as EQIP (environmental quality incentive program), and AWEP (agricultural water enhancement program).

Irrigation Districts might be able to provide in-kind construction and other services to match the funds provided by grants and other sources. GID, for example, has substantial construction capabilities and has demonstrated its expertise by completing a number of large infrastructure projects. Using these resources could result in substantial savings on project construction costs.

## Example Project: Convert Portions of the FSID L-4 and D-13 Lateral Systems to Pipelines

### *Project History and Evaluation*

The Fort Shaw Irrigation District had been working with the Sun River Watershed Group for 15 years to conserve water for the benefit of all users while at the same time improving their ability to deliver water to District producers. Over the years, FSID had implemented a variety of infrastructure improvements but was finding, through experience, that projects which converted open ditch delivery systems to pipelines were producing the most benefit. These types of projects are logical choices for the District to pursue because estimated conveyance efficiencies of the open ditches on FSID were found to be only about 46 percent (Reclamation, 1982). After assessing the system as a whole, FSID and the SRWG targeted the L and the D system ditches as a top priority for future improvement. While the Special Study was in progress, the FSID and SRWG pursued an available opportunity to fund and implement this project.

### *Obtaining Project Funding*

With the assistance of the SRWG, FSID submitted an application to Reclamation under the WaterSMART program. The District requested funding to replace 4,860 feet of very leaky open ditches with PVC pipe. It was estimated that improvements to these delivery systems would result in water savings of 4,158 acre-feet per year. The estimated total project costs were $222,367, of which a grant from Reclamation of $103,717 was requested with the balance to be contributed through labor, equipment and in-kind services by FSID and SRWG. An important component of the grant application was a commitment to improve Sun River flows below the FSID Diversion Dam during the summer irrigation season. Reclamation funded the project for the amount requested.

### *Project Implementation*

Upon receiving project funding, FSID and SRWG worked with Reclamation on National Environmental Policy Act (NEPA) and National Historic Preservation Act (NHPA) compliance, and on obtaining the permits needed before construction could proceed. This included the Corps 404, Cascade Conservation District 310 and DEQ 3A Turbidity permits, and a permit for access across County roads. FSID used a portion of the funds to hire an engineering firm for assistance with project design and construction oversight. Work on the project began during the fall of 2011 and construction work proceeded on schedule, with the project mostly complete by the early spring, 2012. This included replacement of the leaky ditches with PVC pipe, and improvements to headgates and farm turn-outs.

### *Project Follow-Through and Performance Measures*

With the assistance of SRWG, FSID has committed to measuring water delivered to the farms on the ditch system, and to measure return flows in Adobe Creek and flows in the Sun River at Simms for two years following project completion. These flows will be compared to corresponding flow data prior to the system improvements in order to document water savings due to the project. Flow monitoring efforts might continue following the 2-year period, if resources are available.

### *Developing and Implementing a Plan for Sharing Water Savings*

FSID has committed to sharing water savings resulting from this project by increasing Sun River flows by 10 CFS at the USGS gaging station near Simms during the summer irrigation season. FSID is working with TU on this plan, with assistance from the SRWG. An important consideration towards the success of this plan will be adequate communication with other water users on the river to ensure that the targeted flows remain in the river. Although the 10 CFS may not seem huge, it represents a significant improvement to this reach of the river, where irrigation-season flows drop to as low as 30 CFS.

# CONCLUSIONS

The Sun River Watershed Group and others have been working to improve flows in the Sun River while maintaining or improving the production of irrigated agriculture. Because water is not always available in the amounts required to meet all uses, improving Sun River flows has been a persistent challenge. The Watershed Group has found that no one project by itself will solve all of the low-flow problems in the Sun River. This Special Study has identified a number of projects that have the potential to conserve water, and provide shared benefits to irrigators and instream flow in the Sun River. Taken together, these projects might be enough to produce shared benefits and to increase Sun River instream flows at key locations, and during critical times.

Implementing these projects will require a commitment from group members and working together as a team to obtain the necessary funding for design, authorization, and construction. Continued success of the project will require follow-through with operation and maintenance long after the projects are constructed. Developing agreements among parties that allow for sharing a project's water-saving benefits between irrigation and instream uses is critical to the success of these projects, and for achieving the goals of the Special Study.

The Special Study maps out a path for achieving these goals. The process that the group sets out should be flexible too, so that other water-conservation projects that might be identified can be incorporated in the future into the framework set forth in the Special Study.

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# Appendix A: Project Review Spreadsheet Matrix

## Appendix A: Project Review Spreadsheet Matrix View 1.

| | Potential projects were screened for the following initial criteria | | | | Water Saved (Acre-ft) | | |
|---|---|---|---|---|---|---|---|
| | Does the project have the potential to provide water for irrigation and/or instream flows? | Does the project have the potential to adversely affect water users and/or instream flows? | Are there insurmountable hurdles? | Does the project pass the initial screening or can the project be adjusted to pass? If yes, continue. If no, remove from consideration in the Special Study | Winter | Summer | River Reach / Canal Location where saved water can be realized |
| **Category 1 - Delivery Systems** | | | | | | | |
| Investigate the potential for water savings of lining up to 3 miles of the Sunny Slope canal near Augusta. | Yes | There are possible effects to how water in the reach between upstream of the Ft. Shaw Diversion Dam is managed between GID, Fort Shaw, and Broken O. | No | Project passes the initial screening | 0 | 10,000 to 12,000 acre-feet | Sun River Diversion Dam to mouth * |
| Investigate using J-Lake re-regulating storage to help reduce waste water flow to Muddy Creek. | Yes | Waste-water flows in Spring Coulee would be reduced. This could affect users who pump water from that source. | No | Project passes the initial screening | 0 | Potential of 500-8,000 depending on size of storage | Sun River Diversion Dam to mouth * |
| Investigate using Tank Coulee re-regulating storage to help reduce waste water flow to Muddy Creek. | Yes | Waste-water flows in Tank Coulee would be reduced. This could affect users who pump water from that source. | No | Project passes the initial screening | 0 | Up to 5,000 acre-feet dependent on reservoir size | Sun River Diversion Dam to mouth * |
| Investigate using check structures and automation to provide in-canal storage to help reduce waste water flows into Big Coulee, Muddy Creek and other drains. | No | No | No | No due to low water-savings potential | 0 | 248 acre-feet | Sun River Diversion Dam to mouth * |
| Investigate pump back sites on GID's system in order to reduce flows into Muddy Creek and other tributaries. | Yes | Waste-water flows into Muddy Creek and its tributaries would be reduced. This could affect users who pump water from those sources. | No | Project passes the initial screening | 0 | Possibly 1,000 acre-feet per site | Sun River Diversion Dam to mouth * |
| Investigate installing pressurized pipe to deliver water from the GID South Canal to the Simms area and converting some flood irrigated acres to sprinkler irrigation. | Yes | No | No | Project passes the initial screening | 0 | About 1,600 acre-feet | Sun River Diversion Dam to mouth * |
| Investigate installing pressurized pipe to deliver water from the Mill Coulee Canal to the Ashuelot Bench area and converting some flood irrigated acres to sprinkler irrigation. | Yes | No | No | Project passes the initial screening | 0 | About 5,400 acre-feet | Sun River Diversion Dam to mouth * |
| Replacing lateral ditches on the East Bench of GID with low-pressure pipe (GM 100-8). | Yes | Waste-water flows into Muddy Creek and its tributaries would be reduced. This could affect users who pump water from those | No | Project passes the initial screening | 0 | 100 to 200 acre-feet per site | Sun River Diversion Dam to mouth * |
| Investigate reducing waste from FSID C-K canal through a combination of piping and rerouting canal. | Yes | No | No | Project passes the initial screening | 0 | About 1,200 acre-feet | Sun River Downstream of Fort Shaw Irrigation District Diversion Dam |
| Investigate reducing waste to Adobe Creek from FSID L-4 and D-13 system through piping. | Yes | No | No | Project passes the initial screening | 0 | About 4,200 acre-feet | Sun River Downstream of Fort Shaw Irrigation District Diversion Dam |
| **Category 2 - Reservoirs** | | | | | | | |
| Increase the rate at which water can be delivered to Willow Creek Reservoir | Yes | More water would be diverted from the Sun River at times. Diversions would need to occur when prior rights would not be adversely affected. | No | Project passes the initial screening, but landowner concerns with channel erosion would need to be resolved | | Not Available | Sun River Diversion Dam to mouth * |
| Increase the rate at which water can be delivered to Pishkun Reservoir | Yes | More water would be diverted from the Sun River at times. Diversions would need to occur when prior rights would not be adversely affected. | No | Project passes the initial screening | | Not Available | Sun River Diversion Dam to mouth * |
| Increase the height of the Pishkun Dikes to increase the storage of Pishkun Reservoir | Yes | More water would be diverted from the Sun River at times. Diversions would need to occur when prior rights would not be adversely affected. | No | Project passes the initial screening | | 10,000 to 26,000 acre-feet | Sun River Diversion Dam to mouth * |
| **Category 3 - On Farm** | | | | | | | |
| **Category 4 - Miscellaneous Water Management Measures** | | | | | | | |
| Investigate cost/benefit of buying out senior water rights and changing the use to instream | Yes | No | No | Project passes the initial screening | Would depends on change | Would depend on water right change | From existing Water Right point of diversion location to Mouth |

Note: For purposes of the Sun River Special Study, the term 'water saved' refers to the recovery of water intended for a specific use that leaves the system (reservoir, canal, lateral, etc.) without fulfilling the intended function of that use. Examples of loss include (but are not limited to) seepage, evaporation, evapotranspiration, and unrecovered water that enters an irrigation system's 'waste' system.

* Water savings for these projects could decrease the amount of water that needed to be diverted from the Sun River at the Diversion Dam during times of low flow

## Appendix A: Project Review Spreadsheet View 2

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Investigate the potential for water savings of lining up to 3 miles of the Sunny Slope canal near Augusta. | $3,000,000 | $250 to $300 | | | | | | | | Moderate | High | Moderate | Would require engineering design work | GID may be able to install liner | 5 to 10 years |
| Investigate using J-Lake re-regulating storage to help reduce waste water flow to Muddy Creek. | $470,000 for larger reservoir | $50 to $1,000 | $20,038 | $20,038 | $40 | $3 | $730 | $42 | $3 | Moderate | Moderate | Moderate | Feasibility study and Final Design | GID could do much of the construction work | 5 to 10 years |
| Investigate using Tank Coulee re-regulating storage to help reduce waste water flow to Muddy Creek. | $1,650,000 to $3,200,000 | $330 to $640 | $136,428 | $70,346 | $27 | $14 | $730 | $27 | $14 | Moderate | Moderate | Moderate | Feasibility study and Final Design | GID could do much of the construction work | 10 to 20 years |
| Investigate using check structures and automation to provide in-canal storage to help reduce waste water flows into Big Coulee, Muddy Creek and other drains. | $1,600,000 | $6,500 | $68,214 | - | $275 | - | $2,300 | $284 | - | Moderate | Moderate | Moderate | Feasibility studies and Final Design | GID could do much of the construction work | Implementation is not recommended |
| Investigate pump back sites on GID's system in order to reduce flows into Muddy Creek and other tributaries. | $50,000 to $100,000 per site | $60 to $100 | $4,263 | $2,132 | $4 | $2 | $740 | $5 | $3 | Low | Low | Low | Additional sites for pump-back systems need to be located. Designs for each | GID could do installation work | 1 to 5 years |
| Investigate installing pressurized pipe to deliver water from the GID South Canal to the Simms area and converting some flood irrigated acres to sprinkler irrigation. | $3,500,000 | $2,100 | $149,218 | - | $93 | - | $980 | $94 | - | Moderate | Moderate | Moderate | Feasibility studies and Final Design | GID could do much of the pipe installation | 10 to 20 years |
| Investigate installing pressurized pipe to deliver water from the Mill Coulee Canal to the Ashuelot Bench area and converting some flood irrigated acres to sprinkler irrigation. | $7,500,000 | $950 | $319,753 | - | $59 | - | $980 | $59 | - | Moderate | Moderate | Moderate | Feasibility studies and Final Design | GID could do much of the pipe installation | 5 to 10 years |
| Replacing lateral ditches on the East Bench of GID with low-pressure pipe (GM 100-8). | $121,000 | $700 | $5,163 | - | $30 | - | $260 | $31 | - | Low | Low | Low | Feasibility studies and Final Design | GID could do much of the pipe installation | 10 to 20 years |
| Investigate reducing waste from FSID C-K canal through a combination of piping and rerouting canal. | $149,000 | $124 | $6,352 | - | $5 | - | $800 | $6 | - | Low | Moderate | Moderate | Project is Complete | FSID provided construction assistance | Construction Completed |
| Investigate reducing waste to Adobe Creek from FSID L-4 and D-13 system through piping. | $136,000 | $32 | $5,798 | - | $1 | - | $1,000 | $2 | - | Low | Moderate | Moderate | Project is to Construction Phase | FSID will provide construction assistance | 1 year |

**Category 2 - Reservoirs**

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Increase the rate at which water can be delivered to Willow Creek Reservoir | $1,700,000 | | | | | | | | | Moderate | Moderate | Moderate | Feasibility studies and Final Design | GID could do much of the bank stabililzation construction | 10 to 20 years |
| Increase the rate at which water can be delivered to Pishkun Reservoir | Not available | | | | | | | | | Moderate | Moderate | Moderate | Feasibility studies and Final Design | GID could do much of the canal enlargement construction | 10 to 20 years |
| Increase the height of the Pishkun Dikes to increase the storage of Pishkun Reservoir | $29,000,000 | $1,100 | | | | | | | | Moderate | Moderate | High | Feasibility studies and Final Design | GID could do much of the required earthwork | 5 to 10 years |

**Category 3 - On Farm**

**Category 4 - Miscellaneous Water Management Measures**

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Investigate cost/benefit of buying out senior water rights and changing the use to instream | | $21 to $25 | | | | | | | | Low | High | High | Legal work and assessments | TU, DNRC and others can do permitting, legal and feasibility | 1-2 years for study and permitting |

Note: For purposes of the Sun River Special Study, the term 'water saved' refers to the recovery of water intended for a specific use that leaves the system (reservoir, canal, lateral, etc.) without fulfilling the intended function of that use. Examples of loss include (but are not limited to) seepage, evaporation, evapotranspiration, and unrecovered water that enters an irrigation system's 'waste' system.

* Water savings for these projects could decrease the amount of water that needed to be diverted from the Sun River at the Diversion Dam during times of low flow

# Appendix B: Options Identified During Brainstorming that did not fit in the Special Study

These options were dropped from further consideration in the Special Study. There may be opportunity to improve water management in the watershed with these options, but they are outside of the scope of what is needed or could be analyzed in the Special Study at this time.

**1. Review natural Willow Creek inflows to determine if they are declining and why.**
It would be interesting to find out if Willow Creek natural flows are declining, but it is unlikely there is anything that could be done if they are.

**2. Investigate minimum flows and flow gains in the Sun River below the Fort Shaw diversion.**
We already compiled a lot of information on this with the stream gaging and synoptic measurements. This seems to be more a question of how other alternatives might affect gains and losses, rather than an option in itself.

***3. Review winter release rates.***
This already has been done.

***4. Use the internet to track all water diverted to help manage water better.***
This is an ongoing effort. It seems that with the Hydromet system, USGS gages, and the District's resources water is being tracked pretty well.

***5. Look at impacts of changing water use from Ag to other uses, such as pond or yards.***
This really is not an option for improving instream flows in the Sun River. These sorts of changes are occurring, but our intuitions are that they are only a small part of the total water use.

***6. Improve the accuracy of the measurement of water over the Diversion Dam.***
This is an ongoing task; it probably doesn't need to be explicitly addressed as an option in the Special Study.

***7. Add more SNOTEL sites in the watershed.***
This would be helpful, but it would be difficult to quantify the potential water savings.

***8. Cleanup streamflow data to make it more accurate and usable.***
This is a long-term goal, but not a Special Study Alternative.

***9. Trans-basin transfer.***
Not lots of possibilities here because all the surrounding watersheds on the east-side of the Divide are water short too, and any water transfers from the west-side would have to occur through a remote wilderness area.

***10. Investigate cloud seeding.***
It doesn't seem to have a lot of potential because of state and federal laws and policies.

***11. Review the work done by other watershed groups for other ideas on water conservation: Specifically mentioned the review of work done by the Jefferson Watershed Group.***
Work and projects done by other groups was taken into consideration in developing potential projects.

# Appendix C
# Instream Flow Pursuit Sideboards

Finalized at December 10, 2008 meeting

| CONDITION |
| --- |
| |
| Be above board on all acceptable solutions |
| Projects and solutions should provide true "win-win" results |
| Realize there is a risk factor with any changes |
| Projects shall provide 1ransparency and accountability to all project partners |
| Projects shall provide benefits to as many watershed group members as possible and will not adversely affect the interest of any member |
| Projects shall conform to Reclamation and state water laws, including evaluation of return flow issues and adverse impacts to third-party water right holders (ie. PPL) |
| Need to look at "big picture" with all projects |
| Water savings from projects should be shared fairly and equitably |
| With any water savings, need to decide if will be divided up by percentage or at a variable rate |
| Projects will strive to find and provide 100 cfs out of Gibson to meet the 130 cfs FWP instream flow right from Elk Creek to confluence with Missouri River |
| Need to seriously evaluate all risks when swapping water for money |
| Trying to meet agriculture needs at the headgate while looking at opportunities to use saved waste-water to help increase river flows |
| Need to consider impacts to return flows with any project |
| Mechanism to deal with individual farmers risk when pursuing Gibson storage issues |
| If increase storage is pursued, need to look at adverse effects to other water needs |
| Allow capture for filling reservoirs during runoff periods |
| Full reservoirs does not guarantee full water season |
| Need operations review for water savings improvements then rank projects |

**First criteria established were:**

- Project will help irrigation
- Project will benefit the river
- Project will make up for lost reservoir capacity at Gibson
- Project cost will be considered
- Project feasibility to be considered
- Does the project have an adverse impact on other water users
- Project needs to consider actual water saved
- Does the project fit legal and permitting requirements
- How complex is the project
- Location on where the water savings benefits will occur
- Water savings timing and return flow impacts
- Include life-span of the potential projects and the average annual costs for the life of each project

# Appendix D: Basic Water-Sharing Agreement Outline

MEMORANDUM OF UNDERSTANDING

AMONG

______(entity saving water)_________
SUN RIVER WATERSHED GROUP
TROUT UNLIMITED
MONTANA DEPARTMENT OF FISH, WILDLIFE, AND PARKS
and the
U.S. DEPARTMENT OF INTERIOR, BUREAU OF RECLAMATION, GREAT PLAINS REGION, MONTANA AREA OFFICE.

DATED THIS _____ DAY OF ______________, 2012.

This Memorandum of Understanding (MOU) is among the _____________________, the Sun River Watershed Group, Trout Unlimited, and the Montana Department of Fish, Wildlife, and Parks, and the United States Bureau of Reclamation. The purpose of this MOU is to allocate the conserved water from a collaborative water conservation project between irrigation and instream purposes.

## I. Background.

The signatories to this MOU have all, through lengthy involvement, discussion, fundraising, and work, participated in the collaborative water conservation project to ___________________________________________(project name).

The objective of this project is to ______________________(description of the project).

______ (project information)

## II. Objectives.

The signatories to this MOU agree that the following principles are guiding their allocation of conserved water from the collaborative water savings project:

- **Proportional Investment.** Conserved water is allocated in roughly equal measure between irrigation and instream flows because each interest has, and will, invested time, involvement, and has made contributions to the overall success of the project.

- **Fairness.** Conserved water is allocated between irrigation and instream flows to meet the needs of each interest, to the greatest possible extent.

- **Adaptive Management.** While the signatories to this MOU have worked for several years to quantify the water loss, we acknowledge that these are still estimates. The signatories to this MOU acknowledge that as additional data is collected over time after the project is completed, the signatories will re-evaluate the implementation of the water savings agreement according to the two principles articulated above, fairness and proportional investment.

## III. Allocation of Water Savings.

The signatories to this MOU agree to allocate the water savings from the collaborative ___(project name)____ fairly between irrigation and instream flow needs, based on: on-going monitoring of conserved water; adaptive management and learning from successive years of implementation; wet-year management; and, dry-year management. This MOU addresses utilization and allocation of water conserved through __(project activitiy)__ and assumes all other water management operations remain similar to historic methods of operation.

## IV. Implementation of Water Savings Agreement.

The signatories to this MOU propose to administer the water conserved from the ___(project name)_________ as described herein, as follows:

1. For the life of the project, at least one-half of the estimated annual conserved volume of water will be administered by the _____(entity saving water)________, to deliver to its share-holders as needed to meet the District's water delivery obligations for an irrigation purpose. More than one-half of the annual conserved volume of water will be administered for an irrigation purpose under drought conditions, pursuant to the "Dry-Year Administration" paragraph, below.

2. For the life of the project, one-half of the estimated annual conserved volume of water will be administered by the _____(entity saving water)________, in collaboration with Trout Unlimited and the Sun River Watershed Group, for an instream purpose, subject to reduction pursuant to the "Dry-Year Administration" paragraph, below.

3. Allocation of the conserved water for an instream purpose will take place when the Sun River Watershed Group and Trout Unlimited request that the _____(entity saving water)________, deliver water over Diversion Dam. The period of delivery will be restricted to between July 15 and September 30 annually, and requests for an instream delivery will be triggered by Sun River flows between 130 cfs and 40 cfs as measured at the Simms USGS gauge. _____(entity saving water)________, will deliver water over Diversion Dam for an instream purpose up to the volume cap identified below, in the Wet-Year and Dry-Year Administration paragraphs, in consultation with the Sun River Watershed Group and Trout Unlimited. Delivery of the conserved water for an instream purpose down to the Simms USGS gauge will be accomplished pursuant to a water administration agreement, separate from and involving parties not included in this MOU. That separate water administration agreement will conform to Mont. Code Ann. § 85-2-411 ("Water turned into natural channels").

4. Upon reaching the end of the life of the project, or its earlier termination, Trout Unlimited and the Sun River Watershed Group shall terminate and surrender to _____(entity saving water)________, and the _____(entity saving water)________, the conserved water dedicated to instream flows, unless otherwise agreed to by the parties.

5. The parties acknowledge that there is no intent to abandon any portion of the conserved water, nor does this MOU imply any relinquishment of the ownership rights of the _____(entity saving water)________, or the _____(entity saving water)________, over any of the conserved water, whether it is put to an instream or irrigation purpose.

## V. Monitoring and Administration of Conserved Water.

**1. Monitoring of Loss.** Describe monitoring

**2. Wet-Year Administration.** The parties to this MOU agree to a protocol for administration of conserved water in an average to wet-year, based on one-half of the estimated volume of conserved water delivered over Diversion Dam. The determination of an average to wet-year will be made in the spring of each year, based on whether Gibson Resevoir fills. If Gibson Reservoir fills, defined for purposes of this MOU as reaching a minimum of 96,500 acre-feet of storage, then the Sun River Watershed Group and Trout Unlimited may request delivery over Diversion Dam of flows between July 15 and September 30 of each year hereunder, not to exceed one-half of the estimated volume of conserved water.

**3. Dry-Year Administration.** The parties to this MOU agree to a protocol for administration of conserved water in dry years and drought years. The determination of a dry or drought year will be made in the spring of each year based on whether Gibson Reservoir fills, reaching 96,500 acre-feet of storage. If Gibson Reservoir does not fill in a dry or drought year, then the percentage by which Gibson Reservoir fails to fill (the percentage less than 96,500 acre-feet of storage reached as measured on the date of the first releases of stored water) will be the percentage reduction in the volume of water that the Sun River Watershed Group and Trout Unlimited may request for delivery over Diversion Dam.

**4. On-Going Monitoring.** The parties to this MOU agree that on-going monitoring of canal loss, water deliveries, and implementation of this MOU is necessary for its long-term success. Pursuant to the adaptive management principle set out in Section II of this agreement, the data collected from on-going monitoring will provide the basis for any future revision to the estimated volume of conserved water, or other amendment to this agreement, based on the written consent of all arties hereto.

## VI. Agreement in Good Faith.

The parties to this MOU have worked in good faith to come to an agreement, and will continue to work in good faith to implement this water allocation agreement. No party to this MOU shall unreasonably withhold consent to alter its terms in the future, based on the results of the on-going monitoring and the shared learning during its implementation.

Signed this ________ day of __________________, 2012.

________________________________ ________________________________

_____(entity saving water)________, Sun River Watershed Group

________________________________ ________________________________

Trout Unlimited

Montana Dep't of Fish, Wildlife and Parks

_____________________________________

Bureau of Reclamation
United States Department of Interior